Eskom	Standard	Technology

Title:	**Fire Protection & Life Safety Design Standard**	Unique Identifier:	**240-54937450**
		Alternative Reference Number:	**N/A**
		Area of Applicability:	**Engineering**
		Documentation Type:	**Standard**
		Revision:	**2**
		Total Pages:	**163**
		Next Review Date:	**October 2017**
		Disclosure Classification:	**CONTROLLED DISCLOSURE**

APPROVED FOR AUTHORISATION
TECHNOLOGY ENGINEERING
DOCUMENT CENTRE ☎ X4962

Compiled by	Approved by	Authorised by
M. André	M. André	V. Pather
Chief Engineer – Fire Protection	Chief Engineer – Fire Protection	Senior Manager – Auxiliary and Chemical Engineering
Date: 3 October 2014	Date: 3 October 2014	Date: 2014/10/07

Supported by SCOT/SC/TC

N. Nkosi

Low Pressure Services SC Chairperson

Date: 2014/10/07

PCM Reference: **240-53458738**

SCOT Study Committee Number/Name: **SC05-01 / Low Pressure Services**

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

Eskom had a Fire Protection Manual that was written in 2008, which relates mostly to fire protection for Coal Fired Power Stations. This was basically a copy of the NFPA 850 [90] recommended practice. This 'Manual' was not revised and kept up to date regarding new technologies, changing legislation and Eskom requirements. Hence the need for an applicable up-to-date document that specifies the fire protection and life safety philosophies and requirements that Eskom will apply not only on new builds, but also to existing power plants as well as all other divisions throughout Eskom Holdings.

It is hoped that this up-to-date standard will provide more rational, flexible, economic and uniform fire protection approach throughout Eskom, allowing for alternative design based approaches to be explored. This standard captures best practices and the experience gained from various implementations of fire protection systems within Industrial premises, in particular those where power generation takes place.

A Fire Protection/Detection Assessment (FPDA) shall be done in accordance with the Fire Protection/Detection Assessment Standard [3], for any new build, modification or refurbishment to any Eskom Asset. The FPDA shall determine the fire protection and fire detection approach that must be followed for the specific new build, modification or refurbishment. The details of the fire protection requirements shall be in accordance with this standard.

This standard covers the following requirements from a Fire Protection and Life Safety point of view for Eskom assets:

- Passive Fire Protection Requirements
- Active Fire Protection System Requirements (which includes hand-held equipment)
- Specific HVAC Requirements from a fire point of view

Fire Detection requirements for the various areas shall be in accordance with the Fire Detection and Life Safety Design Standard [6].

This standard is written in such a way as to allow users to only search for their applicable system/area, and all fire protection and life safety requirements will be stated for the system/area. This has caused some duplication in this standard but due to the silo approach to fire and life safety this method was utilised to ensure all aspects of fire and life safety for a specific system/area is considered and addressed.

This standard is primarily intended for use in Eskom Holdings Limited Divisions, consequently International and South African standards and codes of practice have been referenced. The principles of system operation and maintenance, as well as the technical information about components and systems, can be applied in other Eskom facilities subject to local authority and code requirements.

2. SUPPORTING CLAUSES

2.1 SCOPE

The scope of this Standard is to guide all persons responsible for the specification, design, construction, commissioning, operating, maintenance and modification of fire protection systems for Eskom Holdings. It shall also assist other parties to determine the most suitable systems to be installed in a specific area within any Eskom asset.

2.1.1 Purpose

The purpose of this document is to provide a fire protection system Standard for persons responsible for the specification, design, construction, commissioning, operation, maintenance and modification of fire protection systems at Eskom Holdings. The Standard aims to capture best practices and the experience gained from various implementations recently carried out on similar power generation projects and all other utilities, across various countries and continents.

This standard is developed to complement SANS 10400-T Fire Protection Systems [55].

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] ISO 9001	Quality Management System
[2] Act 85 of 1993	Occupational Health and Safety Act
[3] 240-54937439	Fire Protection/Detection Assessment Standard
[4] 240-54937454	Inspection, Testing and Maintenance of Fire Protection Systems
[5] 240-56737654	Inspection, Testing and Maintenance of Fire Detection Systems
[6] 240-56737448	Fire Detection and Life Safety Design Standard
[7] 240-56356411	Fire Barrier Seals for Electrical Cable Installations at Power Plants
[8] 240-53114026	Project Engineering Change Management Procedure
[9] 240-53114002	Engineering Change Management Procedure
[10] 240-53113685	Design Review Procedure
[11] EST 32-124	Eskom Fire Risk Management

2.2.2 Informative

2.2.2.1 South African National Standards

[12] SANS 14	Malleable Cast Iron Fittings Threaded to ISO 7-1
[13] SANS 62	Steel Pipes
[14] SANS 121	Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles – Specification and Test Method
[15] SANS 135	Metallic and Other Inorganic Coatings
[16] SANS 191	Cast Steel Gate Valves
[17] SANS 193	Fire Dampers
[18] SANS 198	Functional-control Valves and Safety Valves for Domestic Hot and Cold Water Supply Systems
[19] SANS 226	Water Taps (metallic bodies)
[20] SANS 246	Code of Practice for Fire Protection for Electrical Equipment Installations
[21] SANS 428	Fire Performance Classification of Thermal Insulated Building Envelope Systems
[22] SANS 533-1	Black Polyethylene Pipes for the Conveyance of Liquids
[23] SANS 543	Fire Hose Reels (Semi Rigid Hose)

[24] SANS 664 Wedge Gate and Resilient Seal Valves for Waterworks

[25] SANS 665 Wedge Gate and Resilient Seal Valves for General Purposes

[26] SANS 719 Electric Welded Low Carbon Steel Pipes for Aqueous Fluids (Large Bore)

[27] SANS 752 Float Valves

[28] SANS 776 Copper Alloy Gate Valves – Heavy Duty

[29] SANS 815 Shoulder-ended and Groove-ended Piping Systems

[30] SANS 966-2 Components of Pressure Pipe Systems Part 2: Modified Poly(vinyl chloride)(PVC-M) Pressure Pipe Systems

[31] SANS 1056 Ball Valves

[32] SANS 1091 National Colour Standard

[33] SANS 1123 Pipe Flanges

[34] SANS 1128 Hydrant Systems

[35] SANS 1186 Symbolic Safety Signs

[36] SANS 1143 Mushroom- and Countersunk-head Bolts and Nuts

[37] SANS 1223 Fibre-cement Pressure Pipes and Couplings

[38] SANS 1253 Fire-doors and Fire-shutters

[39] SANS 1476 Fabricated Flanged Steel Pipework

[40] SANS 1551 Check Valves

[41] SANS 1700 Fasteners

[42] SANS 1748-3 Glass Fibre Reinforced Thermosetting Plastics (GRP) Pipes: Part 3 Pipes, Fittings, and Ancillaries for Underground (Buried) Fire Protection Services

[43] SANS 1910 Portable Refillable Fire Extinguishers

[44] SANS 10087:1 LPG Installations Involving Storage Vessels of Individual Water Capacity Not Exceeding 500 Litres

[45] SANS 10087:3 LPG Installation Involving Storage Vessels of Individual Water Capacity Exceeding 500 Litres

[46] SANS 10089:1 Storage and distribution of petroleum products in above-ground bulk installations

[47] SANS 10089:3 The installation, modification, and decommissioning of underground storage tanks, pumps/dispensers and pipework at service stations and consumer installations

[48] SANS 10090 Community Protection against Fire

[49] SANS 10108 The Classification of Hazardous Locations and the Selection of Apparatus for Use in Such Locations

[50] SANS 10131 Above Ground Storage Tanks for Petroleum Products

[51] SANS 10139 Fire Detection and Alarm Systems for Buildings – System Design, Installation and Servicing

[52] SANS 10140:2 Identification Colour Marking: Identification of Hazards and Equipment in Work Situations

[53]	SANS 10177	Fire Testing of Materials, Components, and Elements Used in Buildings
[54]	SANS 10287	Automatic Sprinkler Installations for Fire Fighting Purposes
[55]	SANS 10400-T	The Application of the National Building Regulations Part T: Fire Protection
[56]	SANS 10400-W	The Application of the National Building Regulations Part W: Fire Installation
[57]	SANS 14520	Gaseous Fire Extinguishing Systems – Physical Properties & System Design

2.2.2.2 National Fire Protection Association

[58]	NFPA 2	Hydrogen Technologies Code
[59]	NFPA 11	Standard for Low, Medium, and High Expansion Foam
[60]	NFPA 12	Standard on Carbon Dioxide Extinguishing Systems
[61]	NFPA 13	Standard for Installation of Sprinkler System
[62]	NFPA 15	Standard for Spray Fixed Systems
[63]	NFPA 16	Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
[64]	NFPA 20	Standard for the Installation of Stationary Pumps for Fire Protection
[65]	NFPA 30	Flammable and Combustible Liquids Code
[66]	NFPA 31	Standard for the Installation of Oil-Burning Equipment
[67]	NFPA 37	Combustion Engines & Gas Turbines
[68]	NFPA 54	Natural Fuel Gas Code
[69]	NFPA 55	Compressed Gases and Cryogenic Fluid
[70]	NFPA 58	Liquefied Petroleum Gas Code
[71]	NFPA 59	Utility LP-Gas Plant Code
[72]	NFPA 59A	Standard for the Production, Storage, and Handling of Liquefied Natural Gas
[73]	NFPA 68	Standard on Explosion Protection by Deflagration Venting
[74]	NFPA 70	National Electrical Code
[75]	NFPA 72	Fire Alarm Code
[76]	NFPA 80A	Recommended Practice for Protection of Buildings from Exterior Fire Exposures
[77]	NFPA 85	Boiler & Combustion System Hazard Code
[78]	NFPA 86	Standard for Ovens and Furnaces
[79]	NFPA 101	Life Safety Code
[80]	NFPA 110	Standard for Emergency and Standby Power Systems
[81]	NFPA 211	Standard for Chimneys, Fireplaces, Vents & Solid Fuel-Burning Appliances
[82]	NFPA 214	Standard for Water-Cooling Towers
[83]	NFPA 220	Standard on Types of Building Construction
[84]	NFPA 221	Standard for High Challenge Fire Walls, Fire Walls, and Fire Wall Barriers

[85] NFPA 251	Standard Methods of Tests of Fire Resistance of Building Construction & Materials
[86] NFPA 550	Guide to the Fire Safety Concepts Tree
[87] NFPA 551	Evaluation of Fire Risk Assessments
[88] NFPA 655	Standard for Prevention of Sulfur Fires and Explosions
[89] NFPA 750	Standard on Water Mist Fire Protection Systems
[90] NFPA 850	Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
[91] NFPA 851	Recommended Practice for Fire Protection for Hydroelectric Generating Plants
[92] NFPA 1150	Standards on Foam Chemicals for fires in Class A fuels
[93] NFPA 2001	Standard on Clean Agent Fire Extinguishing Systems
[94] NFPA 2010	Standard for Fixed Aerosol Fire Extinguishing Systems
[95] ALL	NFPA documents referenced in NFPA 850

2.2.2.3 ASTM Standards

[96] ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials

2.2.2.4 Factory Mutual Global Data Sheets

[97] Data Sheet 7-101	Fire Protection for Steam Turbines & Electric Generators
[98] Data Sheet 7-83	Drainage Systems for Ignitable Liquids
[99] Data Sheet 7-88	Flammable Liquid Storage Tanks
[100] Data Sheet 1-6	Cooling Towers
[101] Data Sheet 1-15	Roof Mounted Solar Photovoltaic Panels
[102] Data Sheet 3-7	Stationary Pumps for Fire Protection
[103] Data Sheet 5-3	Hydroelectric Power Plants
[104] Data Sheet 4-1N	Fixed Water Spray Systems for Fire Protection
[105] Datasheet 5-4	Transformers
[106] Datasheet 5-31	Cables and Bus Bars

2.2.2.5 Other

[107] IEC 61400-24,	Wind Generator Systems – Part 24: Lightning Protection, International Electro technical Commission
[108] HIPAP 4	Risk Criteria for Land Use Safety Planning, NSW Department of Planning, 2011.
[109] Zalosh, R.G.	Industrial Fire Protection Engineering, Wiley, 2003.
[110] Tewarson, A.	Generation of Heat and Gaseous, Liquid, and Solid Products in Fires, SFPE Handbook of Fire Protection Engineering, Chapter 3-4, 4th Edition.
[111] Quintere, J.G.	Fundamentals of Fire Phenomena, Wiley, 2006.
[112] McGrattan, K., B	Thermal Radiation from Large Pool Fires, NISTR 6546.

[113] Babrauskas, V.	Heat Release Rates, Chapter 3-1, SFPE Handbook of Fire Protection Engineering, 4th Edition.
[114] BS EN 12101-2	Smoke and Heat Control Systems Part 2: Specification for Natural Smoke and Heat Exhaust Ventilators
[115] BS EN 12101-3	Smoke and Heat Control Systems Part 3: Specification for Mechanical Smoke and Heat Exhaust Ventilators
[116] Allianz Risk	Tech Talk Vol. 8 – Understanding the Fire Hazards of Photovoltaic Systems

2.3 DEFINITIONS

2.3.1 Active Fire Protection

Active fire protection consists of all fire protection systems that are actuated in the event of a fire and need to operate in terms of discharging a suppression medium. These include fire protection by water, water mist, foam and gaseous agents.

2.3.2 Aerosol Protection

This is a particle-based form of fire extinction similar to gaseous fire suppression or dry chemical fire extinction. The aerosol employs a fire extinguishing agent consisting of very fine solid particles and gaseous matter to extinguish fires. The condensed aerosol micro-particles and effluent gases are generated by the exothermic reaction; until discharged from the device, the particles remain in vapor state. They are cooled and "condensed" within the device and discharged as solid particles.

2.3.3 Approved

In the context of fire protection, this signifies components, devices or assemblies having been tested and accepted for a specific purpose or application by a locally or internationally recognised testing laboratory.

2.3.4 Bulk Materials Handling

Refers to the systems used to transport materials from one point to another and includes all conveyors and transfer facilities. The materials transported include coal, ash, limestone and gypsum.

2.3.5 Cable Tunnels

Means cable basements, underground cable spreading areas to, for example, the bag filters, generator transformer, station service building and water treatment plant.

2.3.6 Churning Pressure

The Churning Pressure is the pressure at the outlet of a pump that is running but with zero flow.

2.3.7 Combustible Liquid

Combustible liquids are defined in the NFPA 30 [65] as any liquid with a closed-cup flashpoint at or above 37.8^{o}C.

2.3.8 Competent Person

Means a person who is qualified by virtue of his education, training, experience and contextual knowledge to make a determination regarding the performance of a building or part thereof in relation to a functional regulation or to undertake such duties as may be assigned to him in terms of these regulations.

2.3.9 Controlled Disclosure

Controlled Disclosure: Controlled Disclosure to external parties (either enforced by law, or discretionary).

2.3.10 Critical

Any part or area of plant/facility is seen to be critical if its loss during a fire incident has the potential to cause the following, either immediately or within a 6-12 hour period after the incident:

- A multiple-unit load loss or trip;
- Loss of transmission or distribution capability;
- Permanent loss of production or products; or
- Danger to fire-fighting personnel involved in fighting the fire

2.3.11 Fire Area

Fire Area is an area that is physically separated from other areas by space, barriers, walls, or other means in order to contain fire within that area.

2.3.12 Fire Barrier

A fire barrier is a continuous membrane, either vertical or horizontal as a wall, floor or ceiling assembly that is designed and constructed with a specified fire resistance rating to restrict the spread of fire and the movement of smoke.

2.3.13 Fire Compartment

A fire compartment is an area within a building which is completely surrounded with fire-resistant construction.

2.3.14 Fire Detection

A device designed to automatically detect the presence of fire and initiate an alarm system and other appropriate action – see SANS 10139 [51] (also see NFPA 72 [75]). Some typical fire detectors are classified as follows:

- Heat detector – a device that detects a pre-determined (fixed) temperature or rate of temperature rise.
- Smoke detector – a device that detects products of combustion.
- Flame detector – a device which detects the infrared or ultraviolet, or visible radiation produced by fire.

2.3.15 Fire Detection Panel

An analogue addressable panel used for the termination and programming of point fire detectors.

2.3.16 Fire Detection System

Fire Detection System is a system that consist of detectors, panels and Human-machine Interfaces (HMIs).

2.3.17 Fire Door

Automatic or self-closing door assembly which complies with the requirements contained in SANS 1253 [38], and which is especially constructed to prevent the passage of fire for a specific length of time.

2.3.18 Fire Engineer

A Fire Engineer is a person competent in the application of science and engineering principles to protect people, property, and their environments from the harmful and destructive effects of fire and smoke.

2.3.19 Fire Protection

Method of providing for fire control or fire extinguishment.

2.3.20 Fire-Rated Penetration Seal

An approved product used to seal an opening in a fire barrier for the passage of pipe, cable, duct, etc. so as to maintain a fire rating that is commensurable with that of the fire barrier.

2.3.21 Fire Protection/Detection Assessment (FPDA)

A fire protection/detection assessment is the initial, multi-disciplinary process in which reasonably foreseeable hazards are identified, the severity of the potential harm, to people and plant, is assessed, and reasonable engineering solutions to mitigate these hazards are proposed.

2.3.22 Flammable Liquid

The definition of flammable liquid differs between sources. As such, the definition should be viewed in the context of the document cited. For example:

<u>General Health and Safety Regulation (pertaining to OHS Act)</u>

"Flammable liquid" means any liquid which produces a vapour that forms an explosive mixture with air, and includes any liquid with a closed cup flash point of less than 55^{o}C.

2.3.23 Flash Point

The minimum temperature of a liquid at which sufficient vapour is given off to form an ignitable mixture with the air, near the surface of the liquid or within the vessel used, as determined by a specified test procedure.

2.3.24 Foam-Water Sprinkler System

A piped system that combines foam and piped water to discharge and extinguish over the area to be protected. A piped water supply linked to a control valve is actuated upon operation of the automatic detection system within the area. Upon activation of the control valve, and water flows through the piped system, foam concentrate is introduced into the water supply, with the resulting foam solution discharging over the area affected.

2.3.25 High Hazard

These occupancies are normally commercial and industrial occupancies having abnormal or high fire loads, where the materials handled or processed are of a combustible nature likely to develop rapid and intensely burning fires. This would include turbine areas (with high temperature, high pressure oil) as an example.

2.3.26 Ordinary Hazard

Light non-commercial, commercial and industrial occupancies involving the handling, processing and limited storage of mainly ordinary combustible materials unlikely to develop intensely burning fires in the initial stages. This would include general office areas or coal handling plant areas as examples.

2.3.27 Passive Fire Protection

A Passive fire protection system is preferred above active fire protection. Because it is passive it does not require any mechanical or electrical parts that can fail in the event of a fire. These systems include spatial separation from other areas, containment areas, drainage, fire separation barriers, fire breaks, fire retardant cables, etc.

2.3.28 Redundant

A system or equipment is redundant when it is duplicated to enable a continued service when there is a complete failure of the one system or piece of equipment.

2.3.29 Risk

A quantitative or qualitative measure of an incident loss potential in terms of both the event likelihood and the conditional, aggregate consequences.

2.3.30 Sprinkler System

A network of piping connected to a reliable water supply that will distribute the water throughout the area protected and will discharge the water through sprinklers in sufficient quantity either to extinguish the fire entirely or to prevent its spread. The system, usually actuated by heat, includes a controlling valve and a device for actuating an alarm when the system is in operation. The following categories of sprinkler systems are defined in NFPA 13 [61]

- Wet-Pipe System
- Dry-Pipe System
- Antifreeze System
- Deluge System
- Drencher System
- Combined Dry-Pipe and Pre-action System
- On-Off System

2.3.31 Subsystem

Subsystem refers to a part of the fire protection system to protect a part of the plant such as the generator transformer fire protection subsystem.

2.3.32 System

System refers to the complete fire protection system.

2.3.33 Telecommunication Rooms

Refer to section 6.1.

2.3.34 Total Flooding Extinguishing System (chemical agent or inert gas)

A fire extinguishing system where the extinguishing agent is released throughout a room to flood the total room volume. The extinguishing agent can be a gaseous agent, chemical agent or water mist. Gaseous total flooding systems are typically installed where the presence of water based system would cause a problem (e.g. rooms containing electronic processing equipment) or to protect against shielded or 3-dimensional fire hazards (e.g. flammable liquid pooling underneath equipment or liquid flowing down vertical surfaces). Not suitable for large, open areas like turbine halls.

2.3.35 Unit

A boiler, turbine and generator set and all its dedicated auxiliaries.

2.3.36 Water Spray Curtain System

A water curtain is protection system designed to provide a protective "curtain," or barrier of water in the air between high risk systems and valuable personnel, equipment and facilities. They typically consist of sprinkler heads with the bulb removed and are not to be confused with water drencher systems.

2.3.37 Water Drencher System

A drencher system cools a surface that is exposed to heat and thereby prevents heat from passing to the other side of the surface being wetted. Drenchers are purpose made open nozzles that deliver water at a far higher rate than a water curtain system.

2.3.38 Water Mist System

A network of piping similar to a sprinkler system, except that nozzles deliver a very fine water spray (water mist) to control or extinguish a fire by cooling the flame and fire plume, oxygen displacement by water vapour, and radiant heat attenuation. NFPA 750 [89] provides guidance on these systems.

2.3.39 Water Spray / Water Deluge System

Networks of piping similar to a sprinkler system, except that it utilizes open-head spray nozzles. NFPA 15 [62] provides guidance on these systems.

2.4 ABBREVIATIONS

Abbreviation	Description
AFDA	Automatic Fire Detection and Alarm
ALARP	As Low As Reasonably Practical
ASIB	The Automatic Sprinkler Inspection Bureau
BIPV	Building Integrated Photovoltaic Systems
BLEVE	Boiling Liquid Expanding Vapour Explosion
BMH	Bulk Materials Handling
CoE	Centre of Excellence
CMS	Condition Monitoring Systems
CSIR	Council for Scientific and Industrial Research
CSP	Concentrated Solar Power
DCP	Dry Chemical Powder

Abbreviation	Description
DTS	Deemed to Satisfy
ERP	Emergency Response Plan
ESV	Emergency Stop Valve
FDS	Fire Detection and Alarm System
FM	Factory Mutual
FPDA	Fire Protection / Detection Assessment
FPDR	Fire Protection Design Report
FRF	Fire-Resistant Fluid
HFDL	Heat Flux Damage Level
HRRPUA	Heat Release Rate Per Unit Area
HVAC	Heating, Ventilation and Air Conditioning
IEC	International Electro-technical Commission
I.T.	Information Technology
LPG	Liquefied Petroleum Gas
HMI	Human-Machine Interface
MJC	Multiple Jet Control
n/a	not applicable
NB	Nominal Bore
NFPA	National Fire Protection Association
OHSA	Occupational Health and Safety Act
PMMA	Polymethyl Methacrylate
PV	Photovoltaic
SANS	South African National Standards
UL	Underwriters Laboratories
WTG	Wind Turbine Generator

2.5 ROLES AND RESPONSIBILITIES

The Fire Protection and Life Safety measures detailed in this document are to be implemented by a competent person (as per Eskom Governance and Competency requirements) only. The competent person is to ensure that they fully comply with the Project Engineering Change Management Procedure [8], Engineering Change Management Procedure [9] and the Design Review Procedure [10].

2.6 PROCESS FOR MONITORING

Not Applicable

2.7 RELATED/SUPPORTING DOCUMENTS

[117] 240-56227413 Hydrogen Systems Specification

[118] EST 32-107 Eskom Fire-fighting training programme

[119] EST 32-108 Fire-fighting Organisation

[120] ASIB ASIB 11th Edition Rules

3. DESIGN PROCESS

The user of this Standard has three options to approach the design of the fire protection systems.

a. **Deemed to Satisfy** – Follow the requirements in the South African National Standards (SANS).

b. **Rational Fire Design**

   i. Rational Alternative Code Compliant Design - Follow the requirements in codes and standards other than the South African Nation Standards (SANS).

   ii. Rational Fire Engineered Design - Use a risk based approach and follow acceptable decision making process using fire engineering principles. This will particularly apply to special risk applications.

3.1 DEEMED TO SATISFY APPROACH

SANS 10400 [55] sets out the different possible ways of demonstrating compliance with functional regulations, including a range of prescriptive provisions that are “deemed to satisfy” the requirements of the National Building Regulations. If a design is compliant to SANS 10400 [55] and any of the normative SANS documents referenced within then the design can be classified as deemed to satisfy The use of any document other than a SANS document would require justification as the design would then be deemed a “rational fire design”.

3.2 RATIONAL FIRE DESIGN - CODE COMPLIANT DESIGN APPROACH

Where the South African National Standards does not address a specific fire risk or area of plant a Rational Fire Design will need to be performed and this will usually require looking at codes of practise other than the South African National Standards. For example recommended fire protection measures for power stations can be found in application-specific fire protection design Standards such as those produced by the NFPA.

These solutions have been found to be adequate and are considered best industry practice for their particular environments, Compliance to these codes is acceptable for providing a safe, workable solution to some of the buildings, equipment, areas and sites at Eskom Holdings.

Even though there are many documents which prescribe an adequate code compliant approach, there will always be factors which cannot be accounted for and will require additional engineering. Such factors are:

- Suitability of the fire protection and fire detection components;
- Nature of the site, buildings and equipment;
- Environmental and atmospheric factors specific to the area, such as temperatures, humidity, wind, dust, smog, etc.
- Operations in the areas;
- The level of monitoring and control required for the site as a whole;
- The personnel occupying the buildings as well as using and monitoring the Fire Protection and Fire Detection systems;
- Areas not covered in the documents;

An alternative to complying with the Rational Fire Design – Code Compliant Design approach may be taken by implementing a Rational Fire Design – Fire Engineered Design approach.

3.3 RATIONAL FIRE DESIGN - FIRE ENGINEERED DESIGN APPROACH

A fire engineered solution is now recognised in South Africa as an effective way of meeting fire safety objectives. Although specialist fire safety engineers develop and deliver fire engineering design solutions, designers from other disciplines (such as fire protection, fire detection, HVAC, emergency preparedness, access control, etc.) will often be asked to provide a major input into the way in which the fire safety strategy is developed. Fire safety engineering offers a flexible alternative to code prescriptive approaches, especially when designing for unusual or difficult buildings. A fire safety engineering approach can provide an alternative approach to fire safety, a fact that is recognised in SANS 10400 [55] fire safety code and standards.

Fire engineered solutions may be the only viable way to achieve a satisfactory standard of fire safety in large and complex areas of the power utility assets, and often it is the most effective way of dealing with changes to existing buildings. It can be usefully adopted for certain elements of a building design where the remainder of the building has been designed according to the prescriptive codes. This alternative approach is often the most effective and sometimes the only way to achieve the appropriate level of safety in meeting the latest code requirements for existing buildings.

The use of fire engineering solutions allows beneficial effects to be recognised. For example, the provision of automatic fire suppression can reduce the design fire size, which may in turn lead to a more economic smoke control system design or reduced structural fire protection.

The concept of fire safety engineering provides a framework that enables designers to demonstrate that the functional requirements of legislation are met, or bettered, even though the design solutions adopted fall outside the recommendations of prescriptive codes and guidance.

Fire engineering solutions also allows functional objectives beyond life safety to be addressed, for example, property protection, business continuity, environmental and sustainability objectives.

To achieve this objective, the first step is to understand the functional requirements underlying the prescribed standards. Small departures can then be accepted without a full fire engineering analysis. For example, adding fully automatic fire detection may allow an increase in escape travel distance or an increase in compartment size due to the early alarm and earlier contact with the Fire Service.

However, where there is a greater difference between the building design and the guidance offered by codes, the best way is to follow analytical techniques that demonstrate the control of fire growth, the control of smoke spread and the movement of people which may be required to prove the overall fire safety strategy. The first step in preparing such an analysis is to define the building geometry, functional planning, construction materials and the general use of the building.

While many aspects of the analysis may be quantified, others will require subjective judgment and will be subject to discussion with the building control and fire authorities. They may include, for example, the consequences of fire (which will be subject to the standard of construction and maintenance) or people movement (subject to a motivation or mobilisation time, which may be improved with training or stewarding).

The person who uses this document for the purpose of designing the Fire Protection systems must be a competent person as specified in the National Building Regulation [NBR], section A19 and AZ4.

Eskom Holdings requires that the person responsible shall have at least the following qualifications:

- ***Bachelor Degree in Engineering or higher***
- ***Registered Professional Engineer with ECSA***
- ***At least 4 years of experience in fire engineering***

4. SEPARATION DISTANCE REQUIREMENTS

4.1 SCOPE

This section provides guidance on the methods available for the evaluation of separation distances between buildings, major equipment, activities & processes to limit exposure to radiant heat.

Application of the three design approaches discussed above (Deemed to Satisfy, Code-Compliant or Fire Engineered) is illustrated through various Examples.

4.2 APPLICATION

The first step in determining separation distances is to determine what the design objective is. If the design objective aligns with the objectives typically found in prescriptive codes or standards (e.g. to determine the required spatial separation between buildings or structures to prevent fire spread via radiant heat), a DTS or code-prescriptive design approach could possibly be used. If this is not possible or desirable, a fire engineered design approach will have to be adopted. Situations where a prescriptive approach (DTS or code-compliant) may not be suitable include:

- Where there is no guidance in industry standards or codes for the particular application;
- The recommended separation distances in industry standards and codes cannot practically be met;
- The application under consideration is more hazardous than assumed by the industry standards and codes;
- The application under consideration is considerably less onerous than assumed in the industry standards and codes and a reduction in separation distance is desirable;
- The risk is higher (high value or important structure) than implicit in the industry standards and codes;
- The conditions and assumptions inherent in the prescriptive guidance cannot be met (e.g. the separation distances may be based on the availability of an attending fire brigade).

Application of the three design approaches is illustrated by way of Examples in Section 4.4 through to Section 4.6.

4.3 OBJECTIVES

The objectives of allowing for spatial separation between buildings, equipment, people and plant could involve any of the following:

- Meet code requirements for building approval purposes;
- Prevent building-to-building fire spread;
- Prevent/limit damage to plant or equipment exposed to radiant heat from a possible fire (process equipment, electrical cables etc.);
- Prevent harm to people that could possibly be exposed to radiant heat (plant operators required to perform essential functions, escape routes to be kept tenable etc.);
- Allow for manual fire-fighting activities to be performed;

It is therefore important that the objectives of allowing for spatial separation are clearly understood to enable an informed decision to be made about the adequacy of the provisions.

A disadvantage of following a DTS or rational code-prescriptive design approach is that the objectives are sometimes not clearly defined and the user could be uncertain whether the recommended distances relate to limiting exposure to radiant heat or whether there are other practical reasons. Another problem could be that there could be uncertainty about the basis of the guidance, e.g. what endpoint criteria (e.g. the maximum heat flux) are considered acceptable. As a result, there often are conflicting recommendations between documents from various sources, and the designer is faced with the problem of deciding which source to use. Regardless of source, once selected, all the guidance contained in that document or suite of documents needs to be followed exactly as there is often an inter-dependence between the fire safety features/systems and construction detail. The main advantages of following a code-prescriptive approach are the simplicity of use, and the knowledge that the guidance is generally accepted in industry as best practice.

The advantage of a fire engineered approach is that the exposure hazard and associated consequences are quantified, thereby allowing an informed decision to be made. The main disadvantage is that a high level of fire engineering knowledge is required to perform the analyses. Time constraints and the complexity of modelling required could be additional drawbacks.

4.4 EXAMPLES - DEEMED TO SATISFY DESIGN

4.4.1 Example 1 – Building Separation

<u>Problem statement</u>

It is proposed to construct a new office building on a power station site. An open area adjacent to a warehouse has been identified as a possible location. In order to determine whether the area is large enough to accommodate the office building, it is necessary to determine the required separation distance between the warehouse and the office building.

The warehouse is used for the storage of lubricating oil in 220 L drums. It is a steel framed building with sheet metal cladding, is 50 m long by 25 m wide and has a height of 6 m. It is not sprinkler protected.

The proposed office building is 30 m long by 12 m wide and consist of two storeys. It has 300 mm thick brick cavity external walls (15 mm plaster + 110 mm solid clay brick + 50mm cavity + 110 mm solid clay brick + 15 m plaster). The eaves height is 6 m. The largest window area per elevation is in the longer side of the building and consists of 6 no. equally spaced windows (2 m wide by 1.5 m high) per floor. There is no fire separation between the lower and upper floors.

<u>Solution</u>

SANS 10400-T [55] provides a DTS approach that is amenable to this problem and will therefore be followed. Note that SANS uses the term “Safety distance” for separation distance.

Step 1: Determination of safety distance from warehouse

The warehouse is classified as a J1 occupancy in terms of SANS 10400-T Table 6 [55].

The external wall of the warehouse does not have a fire resistance and is classified as a Type N wall (SANS 10400-T Clause 4.2.1 (c)). As such, the total wall area of the largest elevation is considered as an opening:

$$\mathrm{A} = 50 \times 6 = 300\ \mathrm{m}^2$$

From SANS 10400-T Table 2, under High Fire Load, we find the safety distance to the notional boundary to be 11.0 m.

Table 2 — Safety distances

1	2	3	4
Area of openings in elevation	**Low fire load** **$\leq$ 25 kg/m^2 (timber equivalent)**	**Moderate fire load** **> 25 kg/m^2; < 50 kg/m^2 (timber equivalent)**	**High fire load** **$\geq$ 50 kg/m^2 (timber equivalent)**
	Occupancy class		
	A1, A2, A3, A4, A5, B3, C2, D3, D4, E1, E2, E3, E4, G1, H1, H2, H3, H4, H5, J3, J4	**B2, C1, D2, F1, F2, F3, J2**	**B1, D1, J1**
m^2	**Minimum safety distances** m		
Type F wall (no openings)	1,0	1,5	2,0
< 5	1,0	1,5	2,0
5	1,5	2,0	2,7
7,5	2,0	2,2	3,5
10	2,4	2,5	3,7
30	3,8	4,6	6,2
50	4,5	5,5	7,3
70	5,0	6,0	8,0
90	5,3	6,4	8,6
110	5,5	6,7	9,0
130	5,7	7,0	9,3
150	5,9	7,2	9,6
170	6,1	7,4	9,9
190	6,2	7,5	10,1
210	6,3	7,7	10,3
230	6,4	7,8	10,5
250	6,5	8,0	10,6
270	6,6	8,1	10,8
290	6,7	8,2	10,9
310	6,8	8,3	11,1
330	6,9	8,4	11,2

Step 2: Determination of safety distance from office building

The office building is classified as a G1 occupancy in terms of SANS 10400-T Table 6 [55].

From SANS 10400-T Table 13 [55], it is seen that the external brick cavity wall of the office building is deemed to have a fire resistance in excess of 240 minutes. The wall can therefore be regarded as a type FR wall as it exceeds the 30 minute fire resistance requirement of SANS 10400-T Table 1 for a G1 occupancy.

As the floors are not fire separated, the area of all the openings in the elevation should be considered in the safety distance calculation.

$$\mathrm{A} = 2(6 \times 2 \times 1.5) = 36\ \mathrm{m}^2$$

From SANS 10400-T Table 2 [35], we see that 36 m^2 lies between 30 m^2 and 50 m^2. Opting to use the formula (for Low Fire Load) provided in Table 2 rather than interpolating, we find the safety distance:

$$\mathrm{D} = 2.75\log(\mathrm{A}) - \mathrm{A}^{-0.5} = 2.75\log(36) - 36^{-0.5} = 4.1\ \mathrm{m}$$

Step 3: Separation distance between buildings

The separation distance between buildings is therefore the sum of the two calculated safety distances = 15.1 m.

4.4.2 Example 2 – LPG Tank Separation

<u>Problem statement</u>

It is proposed to install a 5,000 L bulk LPG tank as close as possible to the building where the LPG will be used. What is the closest allowable distance between the tank and the building?

<u>Solution</u>

Requirements for the installation of bulk LPG storage tanks in excess of 500 L is given by SANS 10087:3 [45] (as refer to by SANS 10400-T Clause 4.53.1.1 [55]).

Step 1: Safety distance

Referring to SANS 10087:3 Table 1 below, a safety distance of 7.5 m is found.

Table 1 — Safety distances

1	2	3	4	5	6	7
Water capacity of storage vessel L	**Minimum safety distances** m					
	From above-ground storage vessel to points of transfer[a]	**From above-ground storage vessel to buildings and property boundaries**	**From buried and mounded storage vessel to buildings, property boundaries and points of gas release**	**From sealed surface equipment to building and property boundaries**	**From open flame equipment to building and property boundaries**	**Between above-ground LPG storage vessels**
500 – 2 250	5,0	5,0	3,0	3,0	5,0	¼ of sum of diameters of adjacent storage vessels
2 251 – 9 000	7,5	7,5	5,0			
9 001 – 67 500	9,5	9,5	7,0			
67 501 – 135 000	15,0	15,0	15,0			
135 001 – 265 000	15,0	22,5	15,0			
> 265 000	15,0	30,0	15,0			

[a] For points of transfer or filling points see clause 15 and figure 3.

4.4.3 Example 3 – Diesel Tank Separation

<u>Problem statement</u>

An emergency generator is to be installed at a power station. The generator is to be supplied with diesel from 28,000 L tanks installed in a 6.0 m x 6.0 m bund. It is not proposed to protect the bund with an automatic foam fire suppression system.

The proposed location of the diesel tank is 10.0 m away from an important building housing a control room. Is the tank far enough from the building?

<u>Solution</u>

Step 1: Determine classification of diesel

Guidance for the installation of diesel tanks with a capacity less than 200 m^3 is given in SANS 10131 [50].

SANS 10131 classifies petroleum products in terms of their closed-cup flashpoints as follows:

> **3.9**
> **class**
> class of petroleum product, based on the following classification:
> a) class 0: liquefied petroleum gas;
> b) class I: liquids, subdivided as follows:
> – class IA: liquids that have a closed-cup flash point of below 23 °C and a boiling point of below 35 °C;
> – class IB: liquids that have a closed-cup flash point of below 23 °C and a boiling point of 35 °C or above;
> – class IC: liquids that have a closed-cup flash point of 23 °C or above, but below 38 °C;
> – class II: liquids that have a closed-cup flash point of 38 °C or above, but below 60,5 °C;
> – class IIIA: liquids that have a closed-cup flash point of 60,5 °C or above, but below 93 °C;
> – class IIIB: liquids that have a closed-cup flash point of 93 °C or above

From manufacturer's information, diesel is seen to have a flashpoint of approximtely 55°C. It is therefore a Class II liquid.

Step 1: Determine safety distance

From SANS 10131 Table 2 (see below), the safety distance to an important building is found to be 1.5m. Therefore the proposed location of the diesel tank at 10.0 m away is acceptable.

Table 2 — Minimum safety distances for tanks with class I, II and IIIA liquids at an operating pressure of 17,2 kPa or less

1	2		3	
Individual tank capacity m^3	**Minimum safety distance from the boundary of a property that is built on or can be built on, including the far side of a public road** m		**Minimum safety distance from the near side of a public road, or from the nearest important building on the same property** m	
	Class I liquids	**Class II or IIIA liquids**	**Class I liquids**	**Class II or IIIA liquids**
1,001 to 2,200	3	1,5	1,5	1,5
2,201 to 45,000	4,5	3,0	1,5	1,5
45,001 to 85,000	6	4,5	1,5	1,5
85,001 to 200,000	9	6	3	3

4.5 EXAMPLES – CODE COMPLIANT DESIGN

4.5.1 Example 4 – Transformer separation

Problem

An oil-insulated transformer contains 22,000 L of non-fire-resistant transformer oil. The transformer is installed outdoors in a containment bund 12.0 m long x 7.0 m wide x 0.3m high. What is the minimum distance between the tank and an important building on the site?

Solution

Step 1: Find alternative Standard

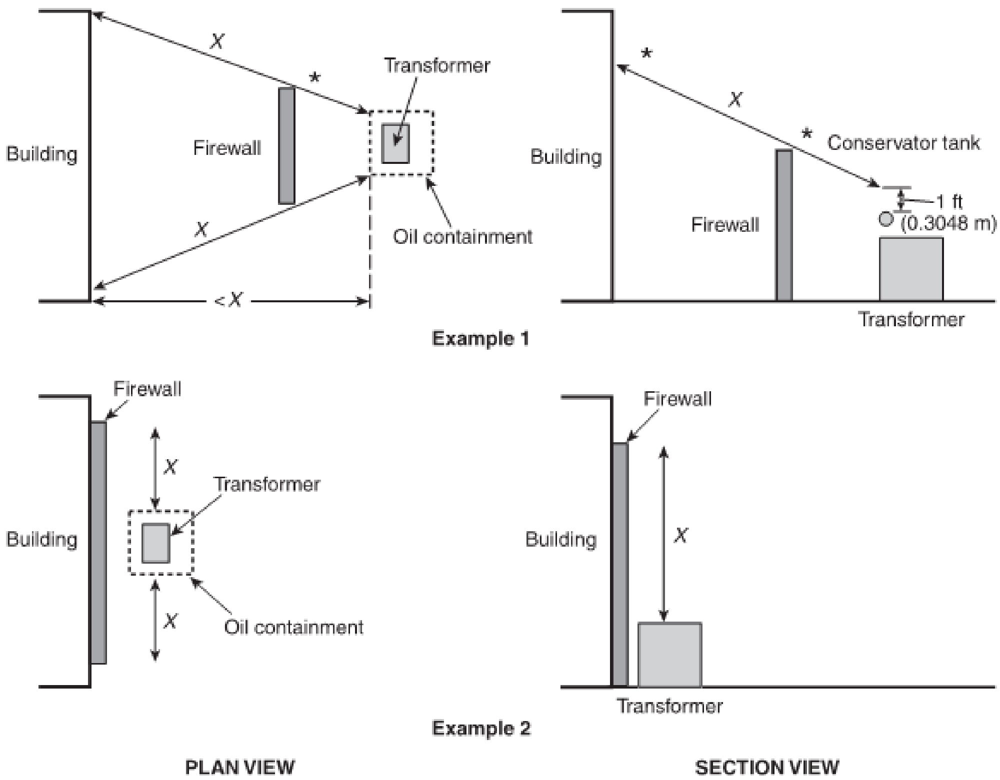
There is no SANS Standard that specifically addresses transformers. As such, it is proposed to perform a rational design by using an internationally accepted Standard as alternative. NFPA 850 [90] has been identified as containing guidance on separation distances between transformers and structures.

Step 2: Determine separation distance

Refering to NFPA 850 Table 5.1.4.3 (see below), the recommended separation distance is 15.0 m.

Table 5.1.4.3 Outdoor Oil-Insulated Transformer Separation Criteria

Transformer Oil Capacity		Minimum (Line-of-Sight) Separation Without Firewall	
gal	L	ft	m
<500	<1,890	See 5.1.4.2	
500–5000	1,890–18,925	25	7.6
>5000	>18,925	50	15



X: Minimum separation distance from Table 5.1.4.3.
*: See A.5.1.4.3.

FIGURE 5.1.4.3 Illustration of Oil-Insulated Transformer Separation Recommendations.

Figure 1: NFPA 850 outdoor transformer separation recommendations.

4.5.2 Example 5 – Building Separation

In this example, the building separation problem given in Example 1 is calculated according to the method presented in NFPA 80A [76].

Whereas the calculation method presented in SANS 10400-T is based on the distance to a notional boundary between buildings (necessitating calculations to be performed for both buildings), the method in NFPA 80A calculates the required separation distance between buildings, i.e. the greater of the separation distance calculated for either building is the required separation distance. The separation distance between the buildings is determined in a way to protect the exposed building and its contents from igniting due to piloted ignition. Determination of separation distances are based on the assumption that neither of the buildings is fitted with means of protection against fire by, for example, sprinklers or fire resistant glazing.

As the warehouse represents the severest hazard, the calculation is performed for the warehouse. The fire is assumed to penetrate the exterior walls of the warehouse within 20 minutes, giving 100% openings in the exposing wall. The width and height of the exposing fire are therefore the same as the façade dimensions, i.e. 50 m x 6 m and 25 m x 6 m respectively.

Step 1: Determine fire severity

The warehouse can be assumed to have a severe fire severity, as the fire load is likely to exceed 74kg/m^2 (wood equivalent), the minimum value listed in NFPA 80A Table 4.3.5.2(a) to be considered as presenting a severe hazard. This can be demonstrated as follows by calculating the minimum litres of oil required to achieve this value:

Multiplying the fire load of 74kg/m^2 by the floor area, the equivalent mass of wood is found:

Fire load = 25m x 50m x 74kg/ m^2 = 92,500 kg

As wood has a heat of combustion of approximately 20,000 kJ/kg, the fire load energy in the building is 92,500kg x 20.0MJ/kg = 1,850,000 MJ. From Table 3 Section 4.6.1.2 (of this document) it is seen that transformer oil has a heat of combustion of 46,400 kJ/kg. The equivalent kilogram of oil is then 1,850,000/46.4 = 39,700 kg. Taking the density of the oil as 880 kg/m^3, this equates to approximately 205 no. of 220 L drums – a number than can easily be accommodated in the building.

Step 2: Guide number

In order to find the appropriate guide number g from NFPA 80A Table 4.4, the ratio between the height and width of the exposing fire needs to be calculated.

W/H = 50/6 = 8.33

Interpolation in Table 4.4 gives the guide number g, as follows:

g = 8.01

Note that NFPA 80A Table 4.4 already is based on a critical incident radiation of 12.5 kW/m^2 and therefore, no further modifications needs to be done with regards to ignition criteria.

The separation distance between the buildings can now be determined as explained below:

D = g x lesser dimension of either the width or height + 1.5 m = 8.01 x 6 + 1.5 = 49.9 m.

It is important to note that the method of determining separation distances in NFPA 80A contemplates Fire Brigade intervention. At locations where Fire Brigade intervention can not be guaranteed within reasonable time, NFPA 80A recommends that the separation distance be extended by multiplying by a factor of up to three.

This result is vastly different to the 15.5 m calculated by the SANS method.

Possible reasons for this could be:

- The SANS method assumes the exposure risk to a building located beyond the notional boundary to be dependent of the size of openings in the façade. Combustibles inside the exposed building could in reality be ignited through any size opening. As an example, the SANS method would have required two similar warehouses to be located 22 m apart.
- SANS Table 2 considers a high fire load to be one that is equal or greater than 50kg/m^2 (wood equivalent). This value however lies within the moderate fire severity grouping of NFPA 80A. SANS 10400 Table 2 therefore significantly underestimates high fire loads (in this case by more than 50%).

Separation distances should be determined using both methods with consideration being given to the worst case result.

4.6 EXAMPLES – FIRE ENGINEERED DESIGN

4.6.1 Applicable Theory

In the following sections, models for calculating the radiative heat flux emitted from buildings fires and fires in the open are presented.

Due to the complexity involved in calculating the radiation from bush fires, gas and dust explosions, deflagrations, fire balls and BLEVE's, these fire phenomena are not discussed. Specialist fire engineering advice should be sought.

4.6.1.1 Thermal Radiation Limits

A performance-based approach to separation distances involves the estimation of the distance from a fire where the calculated heat flux is below a specified value. This value is typically referred to as the acceptance criterion, or heat flux damage limit (HFDL) and depends on the specific objective (preventing harm to people, damage to equipment etc.).

Recommended thermal radiation limits from various sources are given in the tables below. Note that different documents may list slightly different values.

Table 1: Typical thermal heat flux damage limits

Radiation intensity [kW/m^2]	Effect
1.2	Received from the sun at noon in summer.
2.1	Minimum to cause pain after 1 minute.
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur).
12.6	• Significant chance of fatality for extended exposure. High chance of injury. • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure. • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
23	• Likely fatality for extended exposure and chance of fatality for instantaneous exposure. • Spontaneous ignition of wood after long exposure. • Unprotected steel will reach thermal stress temperatures which can cause failure. • Pressure vessel needs to be relieved or failure would occur.
35	• Cellulosic material will pilot ignite within one minute's exposure. • Significant chance of fatality for people exposed instantaneously.

Table 2: Typical thermal heat flux damage limits

B Design guidance: API RP 510: 1990

Thermal radiation intensity (kW/m²)	*Limit*
15.6	Intensity on structures where operators are unlikely to be performing and where shelter is available
9.5	Intensity at design flare release at locations to which people have access and where exposure would be limited to a few seconds for escape
6.3	Intensity in areas where emergency actions lasting up to 1 minute may be required without shielding but with protective clothing
4.7	Intensity in areas where emergency actions lasting up to several minutes may be required without shielding but with protective clothing
1.6	Intensity at design flare release at locations where people are continuously exposed

D Design and assessment guidance – BS 5980: 1990[b]

Thermal radiation intensity (kW/m²)	*Limit*
37.5	Intensity at which damage is caused to process equipment
25	Intensity at which non-piloted ignition of wood occurs
12.5	Intensity at which piloted ignition of wood occurs
4.5	Intensity sufficient to cause pain to personnel unable to reach cover in 20 seconds, though blistering of skin (first degree burns) unlikely
1.6	Intensity insufficient to cause discomfort for long exposures

In most instances where damage to equipment is concerned, a simple radiation damage threshold value as listed above may not be adequate and detailed heat transfer analyses may be required taking into consideration the exposure time and geometry and properties of the material at risk.

4.6.1.2 Heat Release Rate of Fire

Most radiation calculations require that the total heat release rate (HRR) of the fire to be known or estimated.

For ordinary combustibles (non-liquids), there are numerous methods for estimating the HRR of the fire. These methods are not discussed here as ordinary combustibles will seldom be the subject of a separation distance assessment in the context of power stations. In contrast, flammable liquids are stored on site in large quantities and could be the source of large pool fires.

For flammable liquids, the HRR of the fire remains essentially constant once the flame has spread across the liquid pool. The HRR is a function of the mass burning rate $\dot{m}''$, the effective heat of combustion Δh_{eff} of the liquid and the pool area A_f as follows:

$$\dot{Q}_t = \dot{m}''\Delta h_{eff}A_f$$

Equation 1

where $\dot{Q}_t$ = total heat release rate of fire, [kW]

$\dot{m}''$ = mass burning rate of fuel, [kg/s]

Δh_{eff} = effective heat of combustion, [kJ/kg]

A_f = area of pool, [m^2]

Note that the effective heat of combustion Δh_{eff} is less than the net heat of combustion Δh_c (which is determined by oxygen bomb calorimeter) and accounts for incomplete combustion. However, as large–scale measurements of the effective heat of combustion are not readily available, the net heat of combustion is conservatively used, implying that the combustion efficiency is 100%.

The mass burning rate of liquid fuels are given by:

$$\dot{m}'' = \dot{m}''_{\infty}[1 - e(-k\beta D_f)]$$

Equation 2

where $\dot{m}''_{\infty}$ = asymptotic mass burning rate as the pool diameter increases to infinity, [kg.m^{-2}.s^{-1}]

$k\beta$ = mean beam length corrector-flame attenuation coefficient of fuel, [m^{-1}]

D_f = flame diameter, [m]

The above pool burning constants are given in the table below for a few common liquid fuels.

Table 3: Pool Burning: Empirical Constants for a Number of Common Hydrocarbon Fuels [112], [113]

Liquid	Δh_c [kJ kg^{-1}]	$\dot{m}''_{\infty}$ [kg m^{-2} s^{-1}]	$k\beta$ [m^{-1}]
Gasoline	43,700	0.055 (±0.002)	2.1 (±0.3)
Kerosene	43,200	0.039 (±0.003)	3.5 (±0.8)
Transformer oil, hydrocarbon	46,400	0.039	0.7
Fuel Oil (heavy)	39,700	0.035 (±0.003)	1.7 (±0.6)
Crude Oil	42,600	0.060	0.62
No. 2 Diesel Fuel	39,700	0.035	

The SFPE Handbook of Fire Protection Engineering discusses various methods for estimating the surface area of an unconfined fuel spill. For simplicity, the diameter of an unconfined spill will be estimated by assuming that the liquid depth is approximately 13 mm [112], giving the following equation:

$$D_s = 10\sqrt{V}$$

Equation 3

where D_s = spill diameter, [m]

V = volume of liquid spill, [m^3]

4.6.1.3 Emitted Radiation

The emissive power of a flame can be expressed as:

$$E_f = \varepsilon_f \sigma (T_f^4 - T_a^4) = \frac{\chi_r \dot{Q}}{PH_f}$$

Equation 4

where: E_f = emissive power of flame, [kW/m^2]

ε_f = emissivity of flame

σ = Stefan-Boltzmann constant = 5.67x10^{-11} kW/m^2

T_f= temperature of the surface, [K]

T_a= ambient temperature, [K

$\dot{Q}$ = total heat release rate (HRR) of fire, [kW]

χ_r = radiative fraction (fraction of energy lost via radiation)

P = perimeter of flame, [m]

H_f = height of flame, [m]

From this equation it is seen that the emissive power of a fire can be estimated if either:

a) the emissive power is approximated by an empirical correlation, or

b) the flame emissivity and average flame temperature; or

c) the radiative fraction, HRR and flame surface area are known.

Models employing method (a) are usually associated with large hydrocarbon fires. Method (b) is used for calculating the radiation emitted from building openings, and method (c) is used in models for unconfined fires.

4.6.1.4 Flame Emissivity

Radiation emitted from flames depends on the type of fuel and the size of the fire. The radiation comes primarily from the glowing soot particles in the flame, except for clean burning fuels like methanol where the thermal radiation is emitted from the carbon dioxide and water vapour produced by the combustion process. The emissivity of a flame can be expressed as:

$$\varepsilon_f = 1 - \exp(kL)$$

Equation 5

where: k = effective emission coefficient and is fuel dependent, [m^{-1}]

L = effective beam length, [m]

The effective beam length is typically taken as the diameter of the flame, D_f. From Equation 5 it is seen that as the fire diameter becomes large, $\varepsilon_f \rightarrow 1$.

Typical values for the effective flame emission coefficient are given in the table below.

Table 4: Radiative Properties for Soot Particles

Fuel	k [m^{-1}]	Flame temperature [K]
Diesel Oil	0.43	
Furniture (assorted)	1.13	
Petrol (gasoline)	2.0	1240
Wood cribs	0.8	1732

4.6.1.5 Radiative Fraction

In general, the radiative fraction χ_r (fraction of total energy radiated) depends on the type of fuel and the size of the fire. It can vary from as low as 0.15 for low soot producing fuels such as alcohols, to 0.60 for high soot-producing fuels. The radiative fraction initially increases with fire diameter, before decreasing when the fire diameter becomes very large. For very large fires (greater than several meters in diameter), large amounts of soot tend to escape from the combustion zone to congregate around the flames. These relative cool soot particles absorb a considerable amount of radiation, and can reducing χ_r significantly.

Some values for χ_r are given in the table below for relatively small fires.

Table 5: Radiative Fraction for Various Fuels

Fuel	χ_r
Methyl Alcohol	0.16
Heptane	0.33
Kerosene	0.35
Polyurethane	0.59
Polystyrene	0.59
PMMA	0.31
Wood (Douglas Fir)	0.38
Wood (Red Oak)	0.37

The decrease in radiative fraction with increasing fire diameter is shown in the figure below.

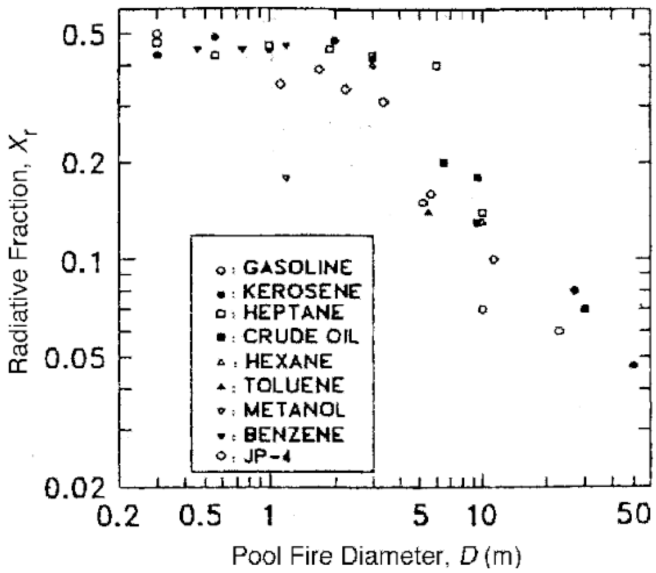


Figure 2: Radiative fraction as function of pool diameter for various hydrocarbon fuel fires

The radiative fraction of large hydrocarbon fuel fires can be estimated from the following empirical correlation [112]:

$$\chi_r = \chi_{r\,max} e^{-kD_f}$$

Equation 6

where $\chi_{r\,max}$ = 0.35, k = 0.05 m^{-1} and D_f is the flame diameter.

4.6.1.6 Radiation Received

The amount of radiation from a fire reaching a target surface depends on the shape and position of the flame relative to the target, as well as the orientation of the target surface. This is expressed as a view factor, F (also called a shape or configuration factor).

The radiative heat flux from a fire received at a target can therefore be expressed as:

$$\dot{q} = \tau F E_f$$

Equation 7

Where: $\dot{q}$ = heat flux received at target, [kW/m^2]

F = view factor (portion of target surface visible to flame)

τ = atmospheric transmissivity

4.6.1.7 Atmospheric Transmissivity

Radiation adsorption by the atmosphere over long lengths can be significant if the flame emits radiation in the spectral absorption bands of the carbon dioxide and water vapour. This effect is usually negligible for sooty flames so that $\tau \approx 1$.

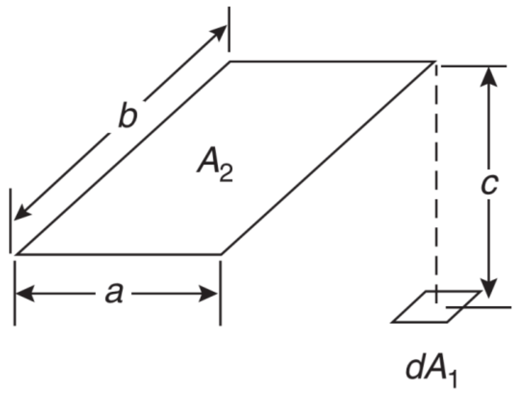
It is however important when the target is screened from the fire by a water curtain, a technique sometimes used to mitigate against radiation exposure.

4.6.1.8 View Factor

In order to facilitate the calculation of the view factor, the flame shape is usually approximated as either a rectangle (flat sheet) or cylinder.

<u>Rectangle</u>

The view factor for a plane element parallel (V) and perpendicular (H) to a rectangle with the normal of the element passing through the corner of the rectangle is given by:

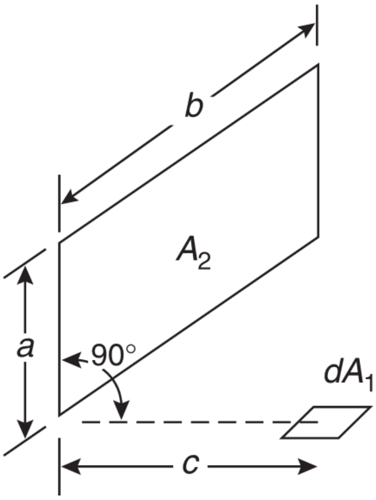


$$F_V = \frac{1}{2\pi}\left(\frac{X}{1+X^2}\tan^{-1}\frac{X}{\sqrt{1+X^2}} + \frac{X}{1+Y^2}\tan^{-1}\frac{X}{\sqrt{1+Y^2}}\right)$$

$$X = \frac{a}{c} \qquad Y = \frac{b}{c}$$

Equation 8

The view factor for a plane element perpendicular (H) to a rectangle with the normal of the element passing through the corner of the rectangle is given by:



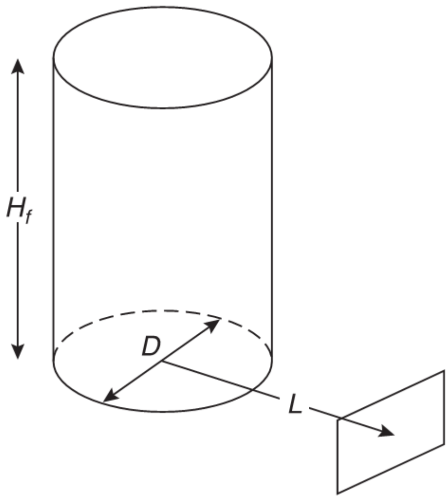
$$F_H = \frac{1}{2\pi}\left(\tan^{-1}\frac{1}{Y} - \frac{Y}{\sqrt{X^2+Y^2}}\tan^{-1}\frac{1}{\sqrt{X^2+Y^2}}\right)$$

$$X = \frac{a}{b} \qquad Y = \frac{c}{b}$$

Equation 9

<u>Cylinder</u>

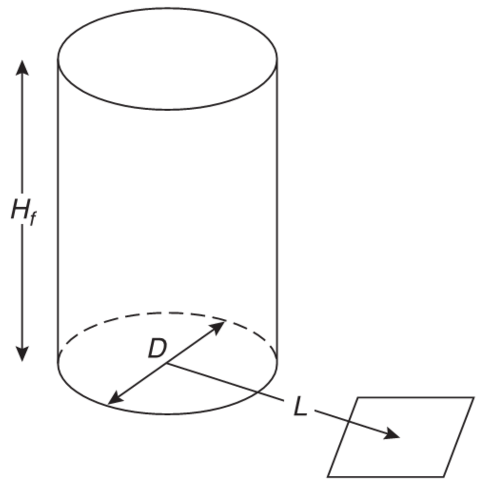
The view factor from a planar element to a cylinder with finite length, and with the normal to the element passing through the axis at the bottom of the cylinder is given by:



$$F_V = \frac{1}{\pi S}\tan^{-1}\frac{h}{\sqrt{S^2-1}} - \frac{h}{\pi S}\tan^{-1}\sqrt{\frac{(S-1)}{(S+1)}} + \frac{Ah}{\pi S\sqrt{(A^2-1}}\tan^{-1}\sqrt{\frac{(A+1)(S-1)}{(A-1)(S+1)}}$$

Equation 10

where A,S and h are defined in Equation 12 below.



The view factor from a planar element to a cylinder with finite length, and with the normal to the element passing through the axis at the bottom of the cylinder is given by:

$$F_H = \frac{(B - 1/S)}{\pi\sqrt{B^2 - 1}} \tan^{-1}\sqrt{\frac{(B+1)(S-1)}{(B-1)(S+1)}} - \frac{(A - 1/S)}{\pi\sqrt{A^2 - 1}} \tan^{-1}\sqrt{\frac{(A+1)(S-1)}{(A-1)(S+1)}}$$

Equation 11

where A,B, S and h are given by Equation 12:

$$A = \frac{h^2 + S^2 + 1}{2S}\ ; B = \frac{1 + S^2}{2S}$$

$$S = \frac{2L}{D}\ ; h = \frac{2H}{D}$$

Equation 12

Maximum View Factor

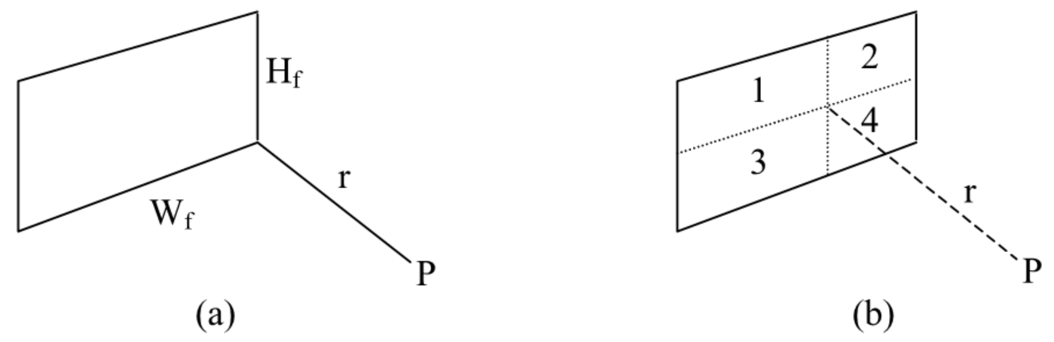
As the maximum heat flux at the target is not necessarily oriented parallel or orthogonal to the flame, the maximum view factor needs to be calculated from:

$$F_{max} = \sqrt{F_H + F_V}$$

Equation 13

Additive Properties

The applicability of the equations for the view factors given above may at first seem limited as it is given to relative to a corner of a rectangle or the base of a cylinder. However, as view factors are additive, the above equations can be used for a wide range of applications by the judicious selection of rectangles and cylinders. The additive property requires that the view factors for each contributory part be calculated from the same receiver, P, as shown below.



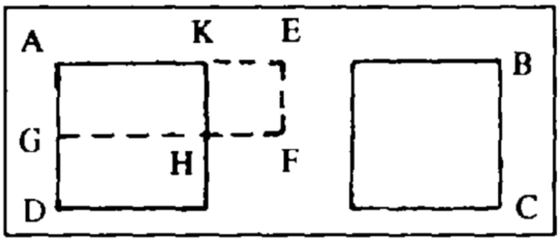
$$F_T = F_1 + F_2 + F_3 + F_4$$

Equation 14

Where: F_T = *total view factor,*

F_n = *view factor for part n*

To illustrate the concept, consider a building with two identical windows in the façade as shown below.



The maximum view factor for both windows will lie in line with point F. As such, the total view factor can be calculated from:

$$F_T = 4(F_{AGEF} - F_{KHFE})$$

<u>View Factor Simplification</u>

If a fire perimeter is irregularly shaped, cylinders or flat plates can be used as surrogates for the perimeter provided that they completely block the view of the fire from the observer. The view factor for a flat plate or cylinder can be used to simplify the calculation as shown in Figure 3.

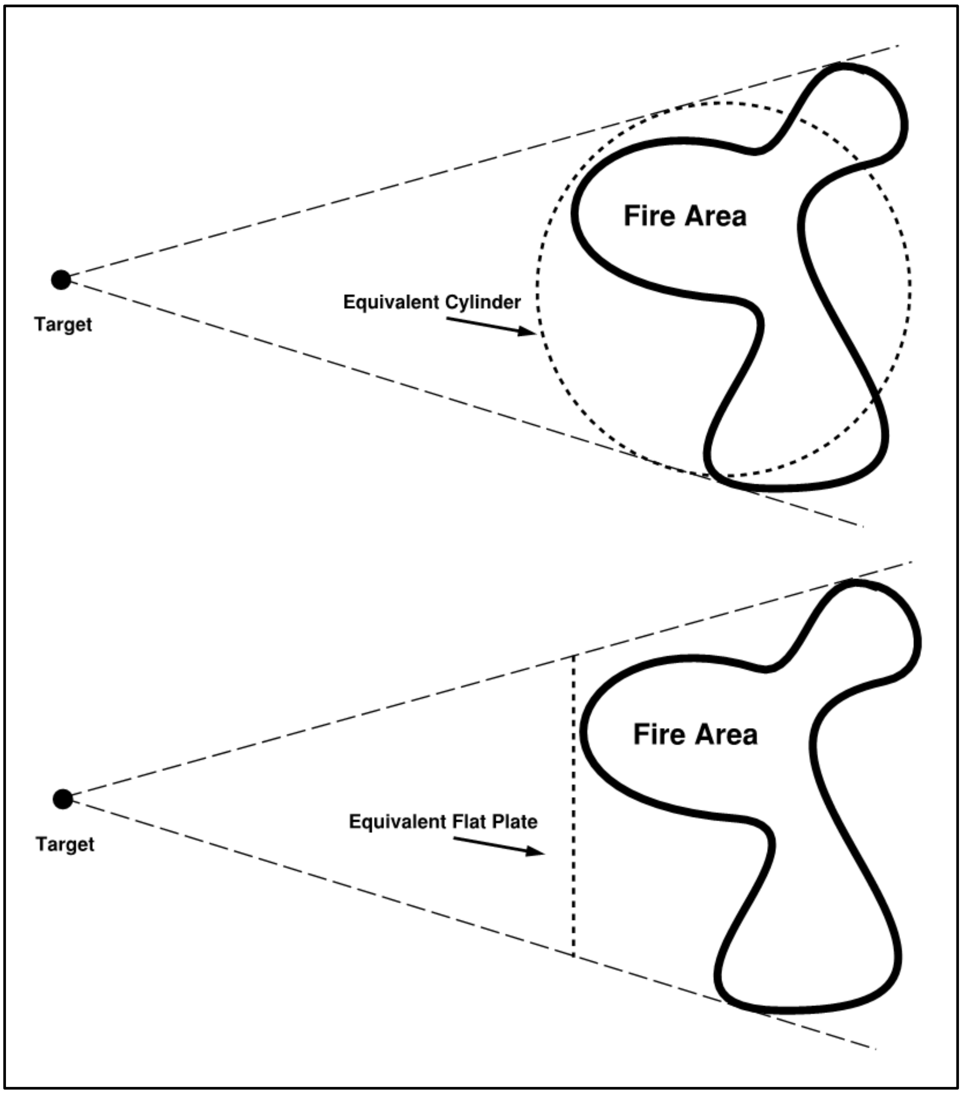


Figure 3: Diagram showing how a cylinder or flat plate is used to simplify a view factor calculation.

4.6.1.9 Flame Characteristics

The diameter of a fire can be estimated from:

$$D_f = \sqrt{\frac{4A_f}{\pi}}$$

Equation 15

where D_f = diameter of fire, [m]

A_f = surface area of a non-circular fire, [m^2]

The flame length for a free-burning fire can be estimated from the Heskestad correlation:

$$H_f = 0.235\dot{Q}^{2/5} - 1.02D$$

Equation 16

where H_f = height of flame, [m]

$\dot{Q}_t$ = total heat release rate (HRR) of fire, [kW]

D_f = diameter of fire, [m]

4.6.1.10 Radiation Emitted from Building Fires

4.6.1.10.1 Compartment Temperature

Building codes require that large buildings be compartmented into smaller areas with fire-rated construction in order to limit the maximum possible size that a fire could possibly reach. External walls are often also required to be fire-rated to prevent fire spread between buildings. Where unprotected openings occur in fire-rated external walls, fire spread between buildings is possible as a result of thermal radiation emitted through window and door openings.

The highest level of thermal radiation emitted through window openings is found when the whole of the compartment is involved in fire and the compartment temperature is high. An enclosure fire can either be fuel controlled or ventilation controlled, depending on the availability of oxygen for combustion. A ventilation controlled fire occurs when the fire size is limited by the amount of air that can flow through openings into the compartment. For relatively high fuel loads, maximum compartment temperatures of around 1040^{o}C has been measured, which represents a maximum radiation intensity of 168 kW/m^2. For low fuel loads (25 kg/m^2 wood equivalent), the compartment temperature is typically around 800^{o}C, which represents a radiation intensity of 84 kW/m^2. These values have been used in the derivation of the separation distances in several prescriptive building codes.

When undertaking a fire engineered approach, it is usually necessary to estimate the maximum compartment temperature that can be expected during a fully involved compartment fire. It is therefore necessary to have an understanding on the factors that influence the maximum post-flash over compartment fire temperature. The compartment temperature depends on the fuel load, the heat loss to the compartment bounding surfaces, and the compartment openings which influence ventilation (air supply for combustion) and the convective heat loss associated with the outflowing smoke.

There are various methods available for estimating the maximum compartment temperature. One such equation is the Law correlation (BS EN 12101-3 [115]) which has been derived from experimental measurements of the maximum compartment temperature recorded for a large number of wood-crib fires in small-scale compartments:

$$T_{comp} - T_a = 6000\frac{[1-\exp(-0.10\eta)]}{\eta^{0.5}}[1-\exp(-0.05\psi)]$$

Equation 17

where: $\eta = \frac{A_T}{A_w h^{0.5}}$,[m$^{-1/2}$]

$\psi = \frac{L}{(A_w A_T)^{0.5}}$,[kg/m^2]

T_{comp} = compartment fire temperature, [K]

T_a = ambient temperature, [K]

A_T = total internal surface area (floor, ceiling and walls minus area of openings), [m^2]

A_W = sum of wall opening area (windows and doors), [m^2]

h = height or weighted average height of openings on walls, [m]

L = fire load [kg, wood equivalent] (heat of combustion of wood is taken as 16 MJ/kg)

Note that the above equation is independent of time, and provides an estimate of the maximum temperature that can be expected in a post-flashover compartment fire. Other methods are available for estimating the compartment temperature as a function of time. These may be required if it is desirable to match the maximum compartment temperature with the fire-resistance period of the bounding construction. These methods are outside the scope of the current discussion and expert advice should be sought if such an analysis is required. Equation 17 should however suffice for general design.

Note that Equation 17 is only applicable to compartments with wall openings, i.e. no ceiling/roof openings.

4.6.1.10.2 Radiation Received

By combining Equation 4 and Equation 7, the thermal radiation emitted from numerous openings in a building façade can be calculated at a target point P from:

$$\dot{q} = F_T \tau E_f = F \tau \varepsilon_f \sigma (T_f^4 - T_a^4)$$

Equation 18

As the flames inside the compartment are optically thick, the emissivity of the opening is $\varepsilon \approx 1$. If the openings are fitted with fire-resistant glazing or the glazing is drenched with water, the emissivity can conservatively be taken as 0.5. As discussed earlier, the atmospheric transmissivity is $\tau \approx 1$ under normal atmospheric conditions.

The view factor is the total view factor from all the openings.

4.6.1.10.3 Calculation Procedure

The above equations can be used in a spread sheet to calculate the required separation distance. This usually will involve an iterative process, depending on the number and size of the openings and whether the openings are in the same plane. The procedure is as follows:

1. Define heat flux damage level (HFDL) depending on objectives (e.g. 12.5 kW/m^2 for piloted ignition of ordinary combustibles).
2. Calculate the maximum post-flashover compartment temperature from Equation 17.
3. Select a trial separation distance, and use the view factors for a rectangular emitter (Equation 8 and Equation 9) and the additive property of view factors (Equation 14) to calculate the total view factor for various combination of openings (e.g. perform one calculation at the centre of the largest opening, another calculation considering 2,3 and more openings) to ensure that the location of the point with the highest view factor is identified.
4. Calculate the radiative heat flux received from Equation 18 and compare with the HFDL.
5. If the calculated radiative heat flux > HFDL, increase the separation distance and repeat from step 3.

4.6.1.10.4 Flames Issuing from Roofs

In buildings where the fire compartment ceiling/roof is not fire-resistant, there is the possibility that flames may spread out through the roof. Estimating separation distances for these situations are complex and falls outside the scope of this document and expert fire engineering advice should be sought.

4.6.1.11 Radiation from Small Unconfined Fires

Radiation from relatively small fires (where soot production is not excessive so that the flame is visible throughout its height) can be estimated from either the point-source model, or by considering the flame to be a cylinder. The models various are discussed below.

4.6.1.11.1 Point-Source Model

In the point-source model, the radiation from the fire is assumed to originate in a point located at the mid-height of the flame as shown in the figure below.

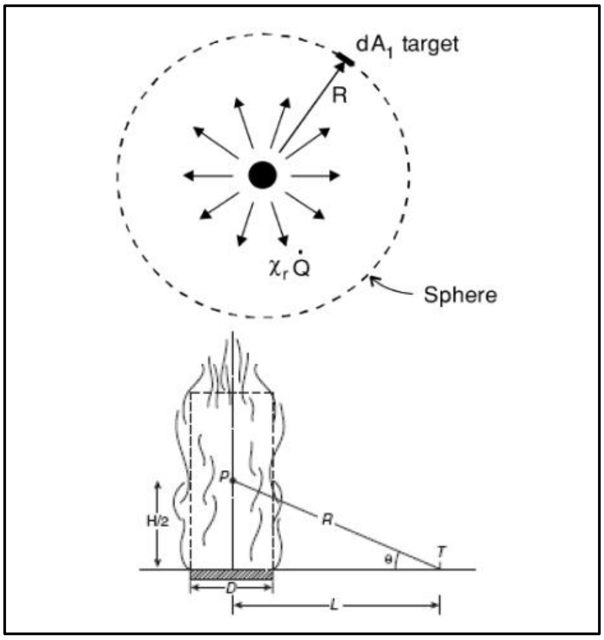


Figure 4: Diagram showing radiation from point-source Model.

The radiation is emitted in a hemisphere and can be calculated from:

$$\dot{q}_r = \frac{\chi_r \dot{Q}_t L}{4\pi R^3}$$

Equation 19

Where: $\dot{q}_r$ = radiation heat flux, [kW/m^2]

χ_r = fraction of heat radiated, [typically 0.35]

$\dot{Q}_t$ = total heat released by fire, [kW]

L = horizontal distance to fire, [m]

R = radial distance from centre of fire to point of interest, [m] Although the point-source model is generally considered accurate at distances greater than twice the fire diameter (L > 2D), there are some experimental evidence that suggests that it is also applicable closer to the fire. This model is used in the BRANZ zone model to estimate the ignition of adjacent objects.

The radiative heat fraction for most fires encountered in buildings is typically around 0.35.

4.6.1.11.2 Cylindrical flame Model

Another model that is often used to estimate the heat flux at a target is the cylindrical flame model.

This model requires the following steps to be performed:

1. Define heat flux damage level (HFDL) depending on objectives (e.g. 2.5 kW/m^2 for occupant tenability).
2. Calculate the fire diameter and flame length from Equation 15 and Equation 16 respectively.
3. Calculate the perimeter of the fire from the effective diameter, $P = \pi D_f$.
4. Estimate the radiative fraction (or use 0.35), and use the total HRR to calculate the emissive power of the flame from Equation 4.
5. For a transmissivity of 1, calculate the radiative heat flux at the target from Equation 7, using the cylindrical view factor equations Equation 10, Equation 12 and Equation 13.
6. If the calculated radiative heat flux > HFDL, increase the separation distance and recalculate the view factors.

It should be noted that the cylindrical flame model is sometimes used in conjunction with an estimate of the average flame temperature. However, as the flame temperature varies with flame height and distance from the axis it is difficult to estimate an average flame temperature. Furthermore, reported values for flame emissivity vary significantly. As such, this approach is not recommended as it is not based on energy conservation principles and does not necessarily ensure that the calculated flame emissive power reconciles with the radiative fraction of the HRR.

4.6.1.12 Radiation from Large Hydrocarbon Pool Fires

Much of the thermal radiation from large soot-producing hydrocarbon pool fires is emitted from the luminous flames visible near the base of the fire. The flames above the luminous base are usually obscured by thick smoke as shown in Figure 5.

The most popular models used for the calculation of the thermal radiation from large pool fires are:

a) Point-source
b) Shokri and Beyler
c) Mudan and Croce
d) McGrattan et al.

The point-source model is considered accurate in the far field, but is considered too conservative within a few fire diameters. The other models (b, c and d) are cylindrical flame models and differ in the treatment of the flame emissive power and flame height.

The model of McGrattan et al. [112] is recommended here because of its conservatism, simplicity of use and the flexibility it provides in assessing the effectiveness of manmade radiation barrier walls in blocking radiation from reaching the target. This model considers the all the thermal radiation to emanate from the luminous flame zone. E_f is regarded as the emissive power of the luminous flame zone, and H_{Lum} is the height of this luminous zone which is lower than the flame height predicted from Equation 16.

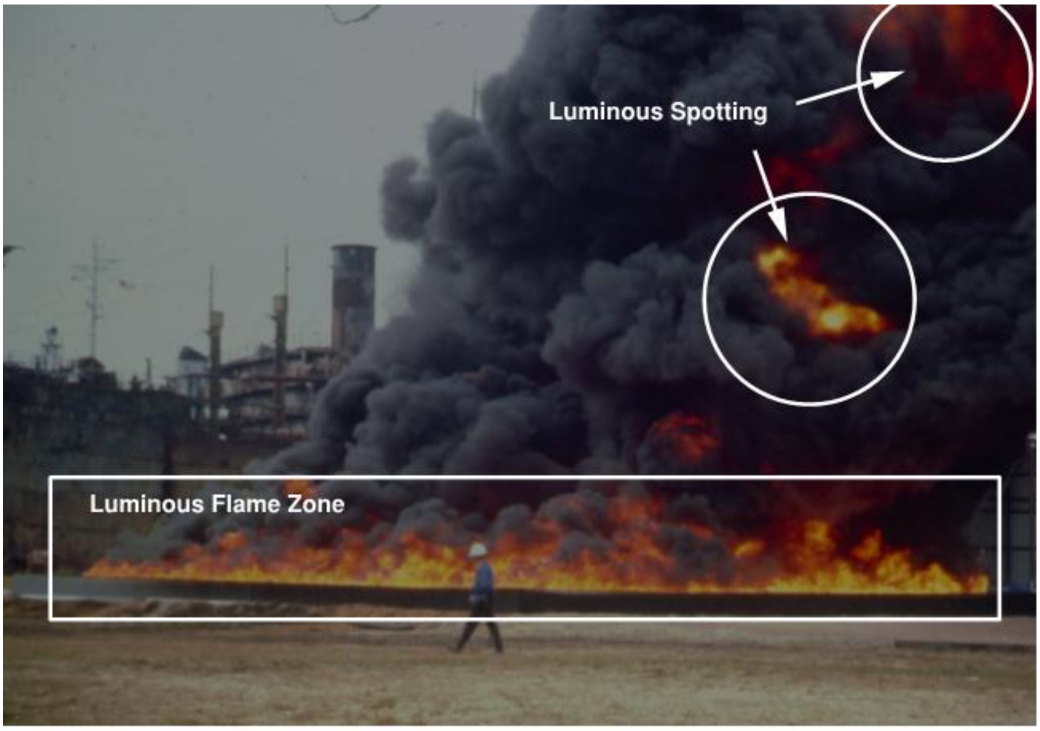


Figure 5: Large hydrocarbon pool fire showing luminous flame region near the base of the fire [112].

The height of the luminous zone is found by rearranging Equation 4:

$$H_{Lum} = \frac{\chi_r \dot{Q}_t}{PE_f} = \frac{\chi_r \dot{q}_f'' A_f}{PE_f}$$

Equation 20

where: E_f = emissive power of flame, [kW/m^2]

$\dot{Q}_t$ = total heat release rate (HRR) of fire, [kW]

χ_r= radiative fraction (fraction of energy lost via radiation)

P = perimeter of flame, [m]

H_{Lum} = height of luminous flame zone, [m]

$\dot{q}_f''$ = heat release rate of fire, [kW m^{-2}]

A_f = area f fire, [m^2]

A constant emissive power (E_f) of 100 kW/m^2 is adopted for the luminous flame zone since it represents an upper bound of the emissive power of most hydrocarbon pool fires. Making use of the correlation for the decrease in radiative fraction with increasing fire diameter (Equation 6), the height of the luminous flame zone H_{Lum} is then found from the equations below:

$$H_{Lum} = \frac{0.35e^{-0.05D_f} D_f \dot{q}_f''}{400} \quad \text{for} \quad D_f \leq 20 \text{ m}$$

$$H_{Lum,max} = 6.4x10^{-3} \dot{q}_f'' \quad \text{for} \quad D_f > 20 \text{ m}$$

Equation 21

where $\dot{q}_f$ = the heat release rate per unit area (HRRPUA), [kW/m^2]

D_f = effective diameter of the fire, or the shortest side of a rectangular fire if the aspect ratio of the longest side to the shortest side exceeds 2.5, [m]

The HRRPUA for hydrocarbon fires can be estimated from Equation 1 and Equation 2 and the values in Table 3.

With the height of the luminous portion of the flame defined, as well as the effective fire diameter or perimeter, the view factor can be determined from equations Equation 10, Equation 12 and Equation 13.

Where the spill is confined to a rectangular dike and the aspect ratio of the longest dimension to the shortest dimension exceeds 2.5, it is not appropriate to assume the fire to be cylindrical with an effective diameter D_f. In these instances the fire perimeter is to be used to calculate the view factor.

4.6.1.13 Radiation Barrier Walls

Although the methodology has been designed to be conservative, it is not conservative when the effectiveness of a barrier in blocking thermal radiation is assessed. This is because the model considers the radiative energy output to be concentrated near the base of the fire rather than distributed over the entire height of the fire.

For example, measurements in Japan of a 20 m diameter crude oil fire showed that 85 % of the radiant energy of the fire was emitted at heights lower than 20 m. The remaining 15 % of the radiant energy was emitted mainly by hot black smoke at higher levels, and by occasional luminous bursts of flame. The HRRPUA for crude oil is approximately 2,000 kW/m^2, thus, the luminous flame height for a 20 m diameter pool fire is 6.4 x10^{-3}(2000) =12. 8 m. In this context, a radiation barrier 13 m in height would be expected to block all of the thermal radiation. To remedy the situation, it is suggested that for the purpose of evaluating a radiation barrier, the emissive power of the flame be reduced by half, from 100 kW/m^2 down to 50 kW/m^2. The flame height is then doubled to ensure that the same value for the product $H_f E_f$ is maintained.
In brief, measurements of the emissive power of the luminous band surrounding gasoline and diesel fuel fires range from approximately 50 to 100 kW/m^2. The value of 100 kW/m^2 is used in evaluating hazards to nearby structures whereas 50 kW/m^2 is used in evaluating thermal barriers. In each instance, the goal is to err on the conservative side.

4.6.2 Example 6 – Separation Distance between Transformer and Valve Station

Problem statement

The transformer in Example 4 is located 20 m from an valve station that requires access by plant personnel during a fire emergency. Is the separation distance adequate to prevent personnel from being exposed to hazardous conditions in the event of the transformer fire?

Solution:

Step 1: Determine the exposure criteria

As the main exposure hazard to personnel is radiant heat, it is necessary to determine a safe design limit.

As the exposure time of personnel is expected to last several minutes, a conservative thermal radiation limit of 1.6 kW/m^2 is adopted (refer Table 2).

Step 2: Selection of large hydrocarbon pool fire model

There are various models that can be used for estimating the radiant heat flux emitted by pool fires. The model of McGrattan et al. [112] is used here.

Step 3: Calculation

The effective fire diameter for the square bund can be calculated for the 6.0 m x 6.0 m bund from Equation 15:

$$D_f = \sqrt{\frac{4A_f}{\pi}} = \sqrt{\frac{4(36)}{\pi}} = 6.77\text{ m}$$

The mass burning rate of the transformer oil can be calculated from Equation 2:

$$\dot{m}'' = \dot{m}''_\infty\left[1 - \mathrm{e}(-k\beta D_f)\right]$$

From Table 3, transformer oil is seen to have an asymptotic mass burning rate $\dot{m}''_\infty$ of 0.039 kg.m^{-2}.s^{-1}, a $k\beta$ of 0.7 m^{-}1 and a heat of combustion Δh_{eff} of 46,400 kJ.kg^{-1}. The mass burning rate is therefore:

$$\dot{m}'' = 0.039[1 - \mathrm{e}(-0.7(6.77))] = 0.039\ kg.m^{-2}s^{-1}$$

The total heat release rate of the fire is therefore from Equation 1:

$$\dot{\mathrm{Q}}_t = \dot{\mathrm{m}}''\Delta\mathrm{h}_{\mathrm{eff}}\mathrm{A}_f = 0.039(46{,}400)(36) = 65{,}146\text{ kW}$$

The heat release rate per unit area $\dot{q}''_f$ is:

$$\dot{\mathrm{q}}''_f = \frac{\mathrm{Q}_t}{\mathrm{A}_f} = \frac{65{,}146}{36} = 1{,}810\text{ kW.m}^{-2}$$

The height of the luminous zone for a fire less than 20 m in diameter is given by Equation 20:

$$\mathrm{H}_{\mathrm{Lum}} = \frac{0.35\mathrm{e}^{-0.05\mathrm{D}_f}\mathrm{D}_f\dot{\mathrm{q}}''_f}{400} = \frac{0.35\exp\left(-0.05(6.77)\right)6.77(1810)}{400} = 7.64\text{ m}$$

Considering the flame as a cylinder and calculating the view factor to a vertical element at the base of the cylinder:

From Equation 12:

$$\mathrm{S} = \frac{2\mathrm{L}}{\mathrm{D}} = \frac{2(20)}{6.77} = 5.908$$

$$\mathrm{h} = \frac{2\mathrm{H}}{\mathrm{D}} = \frac{2(7.64)}{6.77} = 2.257$$

$$\mathrm{A} = \frac{\mathrm{h}^2 + \mathrm{S}^2 + 1}{2\mathrm{S}} = \frac{2.257^2 + 5.908^2 + 1}{2(5.908)} = 3.470$$

$$\mathrm{B} = \frac{1 + \mathrm{S}^2}{2\mathrm{S}} = \frac{1 + 5.908^2}{2(5.908)} = 3.039$$

Calculating the view factor to a vertical element at the base of the cylinder from Equation 10:

$$F_V = \frac{1}{\pi S}\tan^{-1}\frac{h}{\sqrt{S^2-1}} - \frac{h}{\pi S}\tan^{-1}\sqrt{\frac{(S-1)}{(S+1)}} + \frac{Ah}{\pi S\sqrt{(A^2-1}}\tan^{-1}\sqrt{\frac{(A+1)(S-1)}{(A-1)(S+1)}}$$

$$= \frac{1}{\pi(5.908)}\tan^{-1}\frac{2.257}{\sqrt{5.908^2-1}} - \frac{2.257}{\pi(5.908)}\tan^{-1}\sqrt{\frac{(5.908-1)}{(5.908+1)}}$$

$$+ \frac{3.470(2.257)}{\pi(5.908)\sqrt{(3.470^2-1}}\tan^{-1}\sqrt{\frac{(3.470+1)(5.908-1)}{(3.470-1)(5.908+1)}} = 0.0425$$

The heat flux at 20 m is therefore from Equation 7 (E_f = 100 kW/m^2 as per Equation 21):

$$\dot{q} = \tau F E_f = 100(1)(0.0425) = 4.25 \text{ kW}$$

This exceeds the tenability limit of 1.6 kWm^{-2} and we conclude that the separation distance is not adequate. Thus either the transformer needs to be moved further away or a radiation barrier wall needs to be constructed between the valve station and transformer.

Performing the view factor calculations in a spread sheet, the heat flux at the target can be plotted as a function of distance from the fire as shown in Figure 6 below.

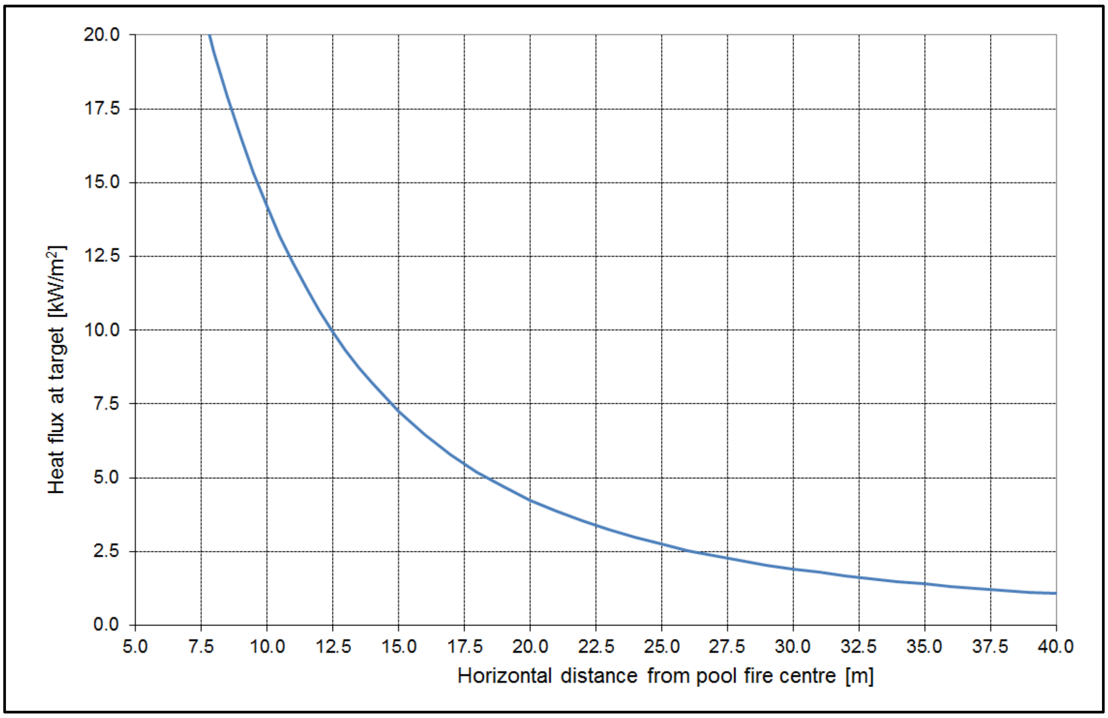


Figure 6: Heat flux at ground level at target as a function of distance from the fire.

From the figure it is seen that the heat flux is 1.6 kW/m^2 at a distance of 33.0 m from the fire.

It is interesting to compare the prediction of this model against the NFPA 850 [90] value as determined in Example 4.

Building separation distance in NFPA 80A [76] (and in the UK) is based on a heat flux of 12.5 kW/m^2 which is generally accepted to be the lowest heat flux below which piloted ignition of cellulosic materials is unlikely to occur.

Considering that the maximum heat flux will be at the centre height of the flame, Figure 6 cannot be used as the heat flux shown has been calculated at the base of the cylinder. To get the heat flux at the centre height of the cylinder, the additive property of view factors can be used by using half the flame height in determining the view factor from Equation 10 and Equation 12, and then multiplying the result by 2.

Performing the calculations for a height H of 7.64/2 = 3.82 m, the graph shown in Figure 7 is obtained. From the graph it is seen that the heat flux is 12.5 $kW.m^{-2}$ at a distance of 12.5 m. This compares favourably to NFPA 850 [90] requirement of 15.0 m in this instance.

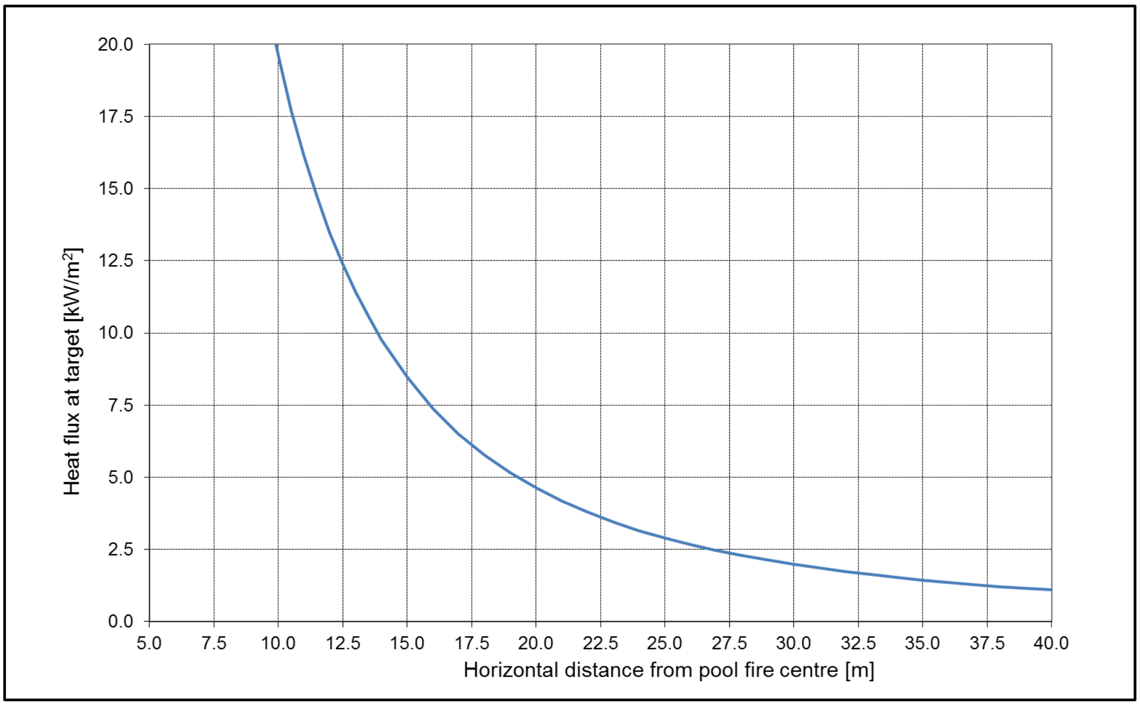


Figure 7: Heat flux at ground level at target as a function of distance from the fire.

4.6.3 Example 6 – Separation Distance between Buildings

In this Example, the separation distance between the buildings in Example 1 is calculated from fire engineering principles.

For a fully involved post-flashover compartment fire, Equation 17, would typically be used to estimate the compartment fire temperature. However, as this equation is based on a fully involved compartment fire, it cannot be used in this instance as the walls and roof do not have any fire resistance and can as such be expected to collapse during the fire (to some degree at least). This would cause large vents to open up which will vent heat from the building.

Therefore, one option is to consider the building as a large open fire. For normal cellulosic materials, the point source model would typically be a candidate method. However, as the building houses primarily lubricating oil, the fire is more likely to resemble a large open hydrocarbon fire. The large hydrocarbon pool fire model of McGrattan will therefore be used.

The effective fire diameter for the building can be calculated from Equation 15 based on the building floor area:

$$D_f = \sqrt{\frac{4A_f}{\pi}} = \sqrt{\frac{4(25)(50)}{\pi}} = 39.89 \text{ m}$$

The mass burning rate of the transformer oil can be calculated from Equation 2:

$$\dot{m}'' = \dot{m}''_{\infty}\left[1 - e(-k\beta D_f)\right]$$

From Table 3, transformer oil is seen to have an asymptotic mass burning rate $\dot{m}''_{\infty}$ of 0.039 kg.m^{-2}.s^{-1}, a $k\beta$ of 0.7 m^{-}1 and a heat of combustion Δh_{eff} of 46,400 kJ.kg^{-1}. The mass burning rate is therefore:

$$\dot{m}'' = 0.039[1 - e(-0.7(39.89))] = 0.039\ kg.m^{-2}s^{-1}$$

The total heat release rate of the fire is therefore from Equation 1:

$$\dot{Q}_t = \dot{m}''\Delta h_{eff}A_f = 0.039(46.4)(50)(25) = 2{,}262 \text{ MW}$$

The heat release rate per unit area $\dot{q}''_f$ is: $\dot{q}''_f = \frac{Q_t}{A_f} = \frac{2{,}262(1000)}{(25)(50)} = 1{,}810 \text{ kW.m}^{-2}$

The height of the luminous zone for a fire more than 20 m in diameter is given by Equation 20:

$$H_{Lum,max} = 6.4x10^{-4}\dot{q}''_f = 6.4x10^{-3}(1{,}810) = 11.6\ m$$

Considering the flame as a two cylinders, each with a height equalling half the luminous flame height, the view factor at the midpoint of the flame is then twice the value calulated from Equation 10.

As combustibles could potentially be ignited inside the office building as a result of radiation received through the windows, it is appropriate to adopt a limiting radiation level of 12.5 kW/m^2. The corresponding view factor can be found from by rearranging Equation 7:

$$2F = \frac{\dot{q}}{\tau E_f} = \frac{12.5}{1.0(100)} = 0.125 \quad \Rightarrow\!\!> \quad F = 0.063$$

Using Excel and plotting Equation 10 as a function of distance (refer to Figure 8), the separation distance corresponding to a view factor of 0.063 is seen from Figure 8 to be 43.7 m. This corresponds well with the value of 49.9 m calculated in Example 5 using NFPA 80A.

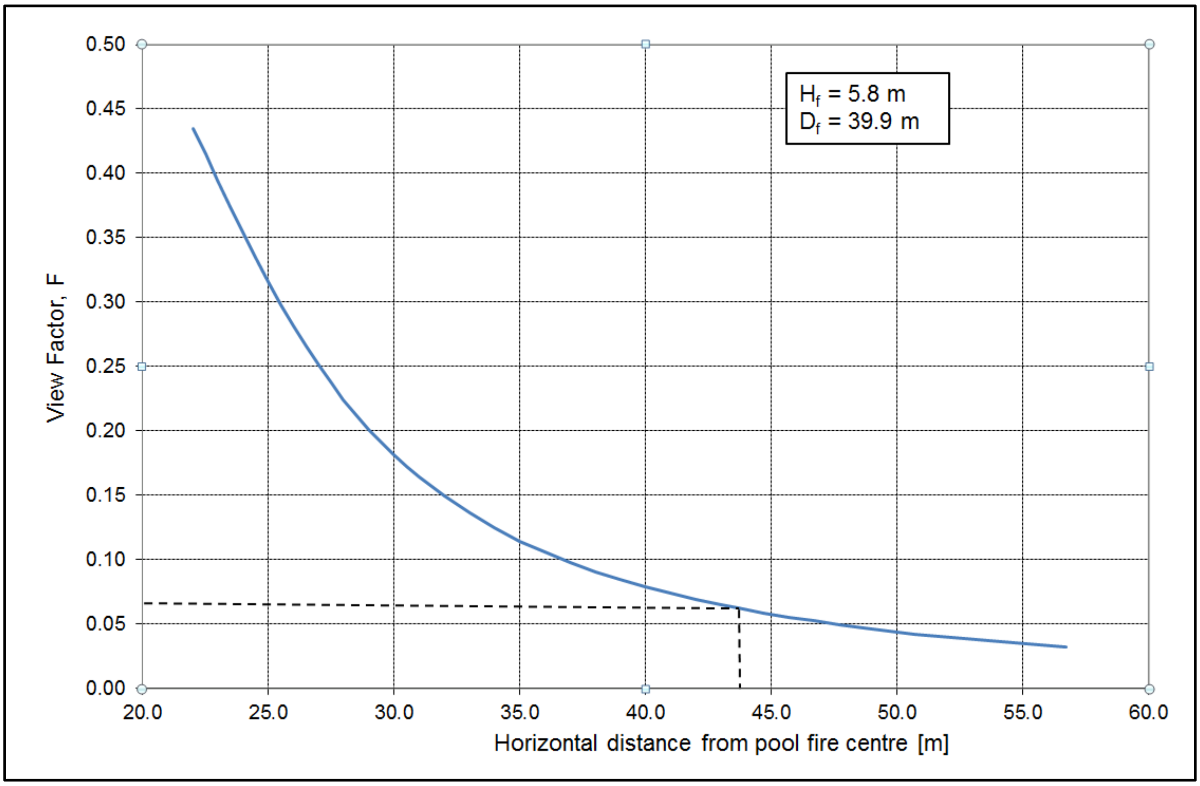


Figure 8: View factor at base of cylinder as a function of distance from the fire.

Performing the calculations to confirm:

$$S = \frac{2L}{D} = \frac{2(43.7)}{39.9} = 2.19$$

$$h = \frac{2H}{D} = \frac{2(5.8)}{39.9} = 0.291$$

$$A = \frac{h^2 + S^2 + 1}{2S} = \frac{0.291^2 + 2.19^2 + 1}{2(2.19)} = 1.343$$

$$B = \frac{1 + S^2}{2S} = \frac{1 + 2.19^2}{2(2.19)} = 1.323$$

Calculating the view factor to a vertical element at the base of the cylinder from Equation 10:

$$F_V = \frac{1}{\pi S}\tan^{-1}\frac{h}{\sqrt{S^2 - 1}} - \frac{h}{\pi S}\tan^{-1}\sqrt{\frac{(S-1)}{(S+1)}} + \frac{Ah}{\pi S\sqrt{(A^2 - 1}}\tan^{-1}\sqrt{\frac{(A+1)(S-1)}{(A-1)(S+1)}}$$

$$= \frac{1}{\pi(2.19)}\tan^{-1}\frac{0.291}{\sqrt{2.19^2 - 1}} - \frac{0.291}{\pi(2.19)}\tan^{-1}\sqrt{\frac{(2.19-1)}{(2.19+1)}}$$

$$+ \frac{1.343(0.291)}{\pi(2.19)\sqrt{(1.343^2 - 1}}\tan^{-1}\sqrt{\frac{(1.343+1)(2.19-1)}{(1.343-1)(2.19+1)}} = 0.063$$

5. GENERAL PLANT DESIGN REQUIREMENTS

5.1 PLANT ARRANGEMENT

The electric generating plant shall be subdivided into separate fire areas for the purpose of limiting the spread of fire and limiting the resultant consequential damage to plant. The overall philosophy shall be that in the worst fire situation, the generating capabilities of not more than one unit will be interrupted.

The following sections highlight the typical requirements to be addressed for all areas. The specific requirements of each section should be evaluated as part of the Fire Protection/Detection Assessment process to determine their relevance, and whether the detailed requirements adequately protect the area or item of equipment in question.

A documented Rational Fire Engineered Design based approach will be taken to the assessment of the separate fire areas aimed at limiting fire spread and minimising loss and maintaining fire life safety. Where appropriate, modelling of parameters such as expected radiant heat flux on targets, smoke transport and toxic species resulting from fires, will be considered in determining the boundaries of such fire areas.

5.2 ESCAPE ROUTES & TRAVEL DISTANCES

Escape routes and travel distances are to be in accordance with SANS 10400 Part T [55]. Where it is not possible to implement these general recommendations due to the non-standard layouts typically found in power stations NFPA 101 [79] shall apply.

A Rational Fire Engineered Design may be necessary where prescriptive methods are inappropriate or excessively onerous.

Any escape route within the power plant and/or its supporting buildings and facilities should be clearly marked and signposted to indicate the available escape routes to a place of relative safety for all operatives.

Typically the exit door from any area which has an occupant population less than 25 people is not required to have an emergency exit sign to meet the recommendations of SANS 10400 Part T [55], however given the nature of the buildings and areas to be protected, and the sheer size and scale of these buildings, the actual requirement to provide exit signage within individual areas should be considered during the Fire Protection/Detection Assessment process. For instance cable tunnels would typically have an occupancy level not exceeding 25 people, however emergency exit signage should be provided from this area to assist with means of escape for any occupants carrying out repairs and maintenance.

All escape signage provided shall be either internally or externally laminated, or be of the photo luminescent type, and shall be designed in accordance with SANS 1186-1, 1186-3 & 1186-5 [35].

5.3 PASSIVE FIRE PROTECTION

5.3.1 Fire Barriers

Fire areas shall be separated from each other by approved fire barriers in accordance with SANS 10177 [53] to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities.

Fire area boundaries shall be determined based on consideration of the following:

- Personnel safety/exit requirements.
- Types, quantity, density and location of combustible material.
- Location and configuration of plant equipment.

- Consequences of losing plant equipment.
- Location of fire detection and suppression systems.

If a fire area is defined as a detached structure, it should be separated from other structures by an appropriate separation distance. Section 4 of this document provides detail on the determination of separation distances to be maintained.

Fire barriers rated to provide a minimum of 2 hours fire resistance (integrity, insulation and stability ratings) in accordance with SANS 10177 [53] shall be provided in the following areas where Section 4 separation distances cannot be met (this will typically be the case for existing power plants where space to implement separation distances will be limited).

Fire barriers with a minimum of 2 hours fire resistance rating shall be provided otherwise in the following areas:

- All areas with major concentrations of cables, such as cable spreading rooms and cable tunnels from adjacent areas [7].
- The control rooms and computer rooms from each other and adjacent areas.
- Areas with major concentrations of electrical equipment such as switchgear rooms and relay rooms, from adjacent areas.
- Battery rooms from adjacent areas.
- Maintenance shops from adjacent areas.
- Main fire pumps from reserve fire pumps and from adjacent areas where these pumps provide the only source of fire protection water.
- Warehouses and combustible storage areas from adjacent areas.
- Emergency diesel generators (including day fuel tanks) from each other and from adjacent areas.
- Fuel oil pumping and/or heating facilities from adjacent areas.
- Storage areas for flammable and combustible liquid tanks and containers from adjacent areas.
- Office buildings from adjacent areas.
- Telecommunication rooms from adjacent areas.
- Fossil fuel-fired auxiliary boiler(s) from adjacent areas.
- Adjacent turbine generators beneath the underside of the operating floor.
- The turbine generator lubrication oil conditioning system and lube oil storage from the turbine building and adjacent areas.
- Wherever so determined by the Fire Protection/Detection Assessment.
- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.
- Windows in fire barriers are to be provided with a fire shutter or automatic water curtain.

Penetration seals provided for electrical and mechanical equipment openings are to be qualified by tests conducted by the SANS, Council for Scientific and Industrial Research (CSIR), or internationally recognised testing laboratories, and approved by Eskom for the relevant location and configuration in which the seals are to be used. Fire barrier seals in power plants shall have a fire rating of 2 hours in compliance with the fire resistance criteria for insulation, stability and integrity as specified by recognised testing institutions and their standards.

5.3.2 Fire Stopping and Intumescent Coating of Cables

The continuity and effectiveness of fire separations shall be maintained around gaps and in gaps between or within building elements (ventilation ducts, service risers etc.). Fire stops shall have a fire resistance rating no less than that required for the fire separation in which they are installed (i.e. 60, 90, 120 minutes).

Fire stops, and the method of installation proposed by any designer or installer shall be identical to those proposed by the fire stop manufacturer. Any deviation from the manufacturer installation methods should be discussed directly with the manufacturer to ensure any proposed alternative method of installation will achieve the same level of fire resistance required.

The material selected for use as a fire stop should be suitable for its application, and the size and type of gap or penetration, and the type of material and construction used in the fire separation.

Penetration seals provided for electrical and mechanical equipment openings are to be qualified by tests conducted by the SANS, Council for Scientific and Industrial Research (CSIR), or other internationally recognised testing laboratories, and approved by Eskom for the relevant location and configuration in which the seals are to be used.

5.3.2.1 Fire Barrier/Seals/Stopping Application Considerations

Effective fire barrier seals can be achieved using various sealant materials.

Irrespective of the method or material selected for the seals, the installation should conform to the following:

- The sealant material and the application rate specified should not affect the performance characteristics of the cables not cause overheating of cables due to heat build-up.
- The fire barrier seal should be capable of withstanding the penetration of water, including firefighting water jets directed at the seals.
- Horizontal seals should be applied to a height just above floor level and dome shaped to prevent the accumulation of oil or water around the penetration.
- The fire barrier seal should be capable of carrying loads where necessary. Any reinforcing required for this purpose should be subject to Eskom's approval.
- The performance of fire barrier seals should not be downgraded by normal ageing, vibration or other environmental conditions associated with the plant or facility.
- The fire barrier sealant material should not crack when the sealant dries or shrinks. If it is necessary for additional sealant to be used on the seal, sufficient curing time should be allowed before its application.
- Fire barrier sealant material should be asbestos free, non-toxic and resistant to chemical attack where specified.
- Fire barrier sealant material should be compatible with the cable insulation or other penetration materials, have good adhesion and be free of volatiles which could adversely affect these materials.
- Fire barrier sealant material may be of the intumescent type capable of expansion under heat to seal voids, cracks or fissures which may exist due to application defects and cable configurations.

5.3.2.2 Fire Barrier/Seals/Stopping Installation Considerations

Installation of the material should be subject to the manufacturer's requirements. The following points should be adhered to during installation.

- Horizontal barriers for vertical penetrations should be sealed on the floor side only.
- Vertical barriers for horizontal penetrations should be sealed on both sides of the barrier to withstand the effects of fire and to ensure that an acceptable finished coating/seal is achieved.
- All tools or equipment used in and around cable penetrations for the application of sealant material should be rounded to prevent damage to the cable insulation.
- Cables should where possible be laid evenly spaced to allow the penetration of sealant materials between the cables. Where cables have not been evenly laid and spaced a sealant material capable

of being applied under pressure should be utilised to effect penetration between the cables in the fire barrier.

- The use of coating materials as fillers will only be approved if the effectiveness of the application is proved and if the fire rating is maintained.
- Combustible or toxic materials used for shuttering during installation should be removed on completions of the seal.
- Mineral wool, ceramic fibre board or other materials with similar properties may be utilized to fill large voids.
- Openings to be sealed should be properly prepared. Oil and excess water should be removed before installation of sealants begins.
- The manufacturer's specified curing time should be allowed during the application process.
- Thickness and volumes for the sealant material applied should be strictly in accordance with the manufacturer's requirements and tests.
- All seals should be provided with a final layer or coat to provide a smooth finish.
- The sealant material utilised should allow for the replacement of cables or additional cables or any other penetration component to be installed without disturbing the major portion of the seal.
- If the sealant material utilised is subject to excessive expansion, steps should be taken to ensure that the bulk of the sealant material remains within the seal when expansion occurs during application.
- Seals may be of the rigid or flexible type.
- If coating of cables is necessary to assist the adhesion of the sealant material, or if sections of cables need to be coated on either side of the seal, this should only be done with Eskom's approval.
- If reinforcing of the seals is necessary the type, pattern and anchoring of the reinforcing should be approved by Eskom.
- Where openings cannot be completely sealed due to work in progress the use of temporary seal bags is recommended.
- The method of application and materials utilised should be approved by Eskom.
- Penetration seals should be uniquely identified as a fire barrier with the specified fire rating of the barrier. Reinstatement or repairs to the barrier should be in accordance with the relevant specification.

5.3.3 Building Construction Materials

The construction materials used in the boiler or turbine generator building, or other buildings critical to power generation shall meet the definition of non-combustible in according to SANS 428 [21]. A Rational Fire Engineered Design based approach may be incorporated to achieve alternative building solutions where prescriptive methods are inappropriate or excessively onerous.

5.3.3.1 Building Construction Materials – Surface Finishes

All material finishes, other than those applied to floors, shall meet the Surface Fire Index ratings as detailed within SANS 10400 Part T [55], Table 17. Any finishing material chosen should be tested in accordance with SANS 10177 [53], in particular Part 3.

All material finishes applied to as floor coverings shall meet the Fire Index coverings detailed SANS 10400 Part T [55], Table 18 and be tested in accordance with SANS 10177 [53], in particular Part 4.

5.3.4 Drainage

Provision shall be made in fire areas of the plant for removal of all liquids directly to safe areas as well as confinement of liquid spills to a defined catchment area as per NFPA 13 [61], NFPA 15 [62], NFPA 850 [90] and NFPA 851 [91] on the provisions to be adopted to remove fire water from the area of discharge, with the recommendations followed within FM Data Sheet 7-83 [98] for the removal of flammable liquid.

During the Fire Protection/Detection Assessment process consideration should be made to adopting one, all, or a number of the following prevention measures:

- Floor drains
- Floor trenches
- Curbs or bunds for containing or directing drainage
- Provision of key generating equipment on pedestals
- Pits, sumps, and sump pumps
- Fire traps within floor drains for combustible/flammable liquid applications.
- Provisions for storing run-off fire-fighting water that will contain contaminants, which may potentially impact upon the surrounding environment (ground contamination, contamination of natural water courses etc.).

Where gas suppression systems are installed, drains and appropriate dampers shall be provided with adequate seals, or the gas suppression system shall be sized to compensate for the loss of suppression agent through the drains.

5.4 LIFTS

The lift operation and design shall conform to the requirements stipulated for a 'fireman's lift' (refer to application of the National Building Regulations, SANS 10400 Part T [55]). It is to be positioned such that it can be safely used during a fire situation for the transport of fire-fighting personnel and equipment.

Any lift to be used by the Local Fire Service or the Eskom Emergency Fire Response team should be designed in accordance with the recommendations detailed within SANS 10400 Part T [55].

5.5 FIRE DETECTION SYSTEM

The fire detection and alarm system will comprise a site-wide analogue addressable distributed fire control network. The status of all fire related devices, including but not limited to suppression systems, vents, dampers, fans, detectors and manual call points, will be physically connected to strategically located sub Fire Detection Panels which report to a master Fire Detection Panel in a location suitable for ready access by the responding fire services and other control personnel.

All fire system alarms and status points will be interfaced to the site SCADA system by means of a high level interface. Graphic displays shall be incorporated into the site SCADA system rather than by means of independent fire system graphics. This is so as to promote familiarity of normal / abnormal fire alarm conditions with operators. Video Based Fire Detection displays will be incorporated into the standard operational CCTV system displays.

The design of the fire detection and alarm system shall be in accordance with the Fire Detection and Life Safety Design Standard [6].

5.6 CLASSIFICATION OF HAZARDOUS LOCATIONS

SANS 10108 [49] covers the classification of locations in which fires or explosions can occur due to the presence of flammable gases, vapours, dust or fibrous material in the air, in order to permit the proper selection of electrical apparatus and mechanical equipment to be used in such locations.

This standard will give the designer an indication of where certain types of rated equipment should be used. The Eskom standard Fire Detection and Life Safety Design Standard [6] also gives guidance on the classification of hazardous locations.

5.7 VENTILATION AND AIR-CONDITIONING

The main functions of the ventilation system, as part of the fire protection system and overall fire strategy for the area under consideration are:

- To assist with reducing the concentration of smoke and/or gases in an identified area.
- Typical day to day ventilation does not constitute a smoke control system as a system designed for smoke control in fire operation would include fire rated fans and automatic controls to operate the system upon activation of the automatic detection and alarm system. Should a dedicated smoke control system be required for a given area it should be designed by a competent fire engineer, with a proven track record in designing and specifying such systems.
- To help prevent the migration of smoke and/or gases from a fire area to adjacent or other fire areas.
- To maintain the fire resistive integrity of plant components and elements such as floors, partitions, roofs and walls affected by the installation of air duct systems.
- To permit the air duct system in a plant to be used for the additional purpose of smoke control should its ductwork route and design not place other occupants and areas at risk through migration of smoke into their escape routes.
- To facilitate fire brigade intervention

A properly designed ventilation system will reduce fire hazards by:

- Reducing vapour, fumes and gases to a safe concentration level.
- Maintaining tenable conditions for occupants escaping from the building and to also allow for effective fire brigade intervention.
- Control airborne dust concentration levels to reduce the possibility of dust explosions.

5.7.1 Air Distribution/Air Intakes

Fresh air supply intakes should be located remotely from the exhaust air outlets and smoke from other fire areas, to minimize the possibility of contaminating the intake air with products of combustion.

Air ducts that pass through protected fire areas and which do not serve such fire areas, should not degrade the fire integrity of the fire barriers. Where a ventilation duct penetrates a fire barrier, a fire damper compatible with the fire rating of the barrier should be provided, unless the duct itself is protected throughout its length with a fire-rated material equivalent to the rating of the fire barrier.

Any material used for ducting in corrosive atmospheres, shall be suitable for such atmospheres.

5.7.2 Ventilation and Fire System Interface Control

Where practical, power supply and controls for any mechanical ventilation system should be run outside the fire area served by the system. The dampers are to be fail-safe, with cabling and cabling support systems rated to operate under fire conditions to the same extent as the fire rated ventilation system.

Each air distribution system should preferably be interlocked with a fire protection system to automatically shut off the electrical supply to the return fans, supply fans and extraction fans serving the fire area from which the fire signal was received.

Provision should be made for manually operated switches at the Fire Detection Panel to manually control the smoke management system and reinstate operation of the ventilation system after the automatic shut-off has operated. The controls should be incorporated into and associated with the Fire Detection Panel in the form of an adjacent Fire Fan Control Panel.

5.7.3 Fire Dampers

Fire dampers shall be provided and installed wherever ductwork systems pass through floors, fire compartment walls and wherever deemed necessary by the Fire Officer or other relevant statutory authority. The complete fire damper assembly shall have a fire resistance rating equal to the fire barrier it penetrates and rated in accordance with SANS 193 [17].

Fire damper installation shall be in accordance with the manufacturer recommendations or in accordance with SANS 193 [17]. The installer shall submit to Eskom evidence of the fire rating of the damper in accordance with SANS 193 [17].

Under no circumstance shall the fire damper rely on the associated ductwork for support. They shall be installed in suitable fire damper frames, or alternative fixings subject to discussion with the Eskom Project Design Engineer.

Unless otherwise stated the damper shall be held open outside of the air stream by a fusible link mechanism which is rated to activate at 72°C.

The fire damper shall be linked to a central point (typically the control room) to remotely indicate that a fire damper has actuated and is in the open/closed position.

An access panel in the air duct is to be provided at each damper for inspection purposes. Fire dampers should, when moved to a closed position, be manually or automatically operable from an area inside or immediately outside of the fire area served.

Fire dampers should be clearly marked to identify the location in relation to the fire detection zone and damper number. This requirement also refers to technical drawings of the ventilations system.

5.7.4 Fire Damper Access Panels

An access panel in the air duct is to be provided at each damper for inspection purposes. Fire dampers should, when moved to a closed position, be manually or automatically operable from an area inside or immediately outside of the fire area served.

Fire dampers should be clearly marked to identify the location in relation to the fire detection zone and damper number. This requirement also refers to technical drawings of the ventilations system.

5.7.5 Smoke Control & Ventilation Systems

The aim of a smoke ventilation system is typically to provide conditions that are safe for occupants to evacuate from. It may be possible to combine any smoke extract system with the day to day ventilation system provided. Careful consideration to the rating of any extract fan selected should be made as a fan typically chosen for day to day ventilation will not be able to operate under fire conditions given the increased smoke temperatures to be extracted. The design of the system, and the competency of any staff member with design responsibility, should be carefully considered.

SANS 10400 Part T [55] and BS EN 12101 Parts 2 [114] and Part 3 [115] provide guidance on the design of mechanically assisted or natural smoke and heat ventilation systems.

Care should be taken when designing any system to ensure discharge points do not affect walkways or escape routes in other areas.

Dampers shall have fully welded galvanized steel casings and spigot connections. Damper blades shall be formed of stainless steel and of sealed aerofoil riveted double skin construction. The design shall ensure low closed blade smoke leakage at ambient temperature.

Dampers shall fail safe by means of an electrical thermal release which operates at 72°C or by loss of power. Smoke control dampers shall be arranged to fail safe in the event of mechanical or electrical failure.

The dampers shall be of the motorised open/spring closure type and all dampers shall be complete with a motor actuator suitable for a 230v supply. The damper shall be arranged to open when a power supply is provided to the actuator or alternatively by depressing the switch on the motor.

The dampers shall have suitable voltages and controls to allow the dampers to be controlled by the smoke control system and/or fire alarm system

Closure of the damper shall be achieved by:

- Fusible link failure due to high temperature
- Interruption of mains power
- Depressing the lighted indicator

The damper motor shall be provided with two auxiliary contacts for remote monitoring of the damper open and closed status, with means of monitoring the system provided within the Main Control Room.

The dampers shall be complete with installation frames or alternative fixing method (depending on the type of fire rated structure). The dampers shall be mounted with the installation frames in accordance with the manufacture’s recommendations.

On large ducts, it may be necessary to have a multi-damper assembly mounted within a frame.

The actuator and control assemblies shall be supported in accordance with manufacturer recommendations.

Dampers shall incorporate visual indication of the damper blade position.

Operation of all smoke dampers shall be demonstrated to the Eskom design engineer as part of the commissioning and handover of any system.

Each damper shall be tested during commissioning and the commissioning documentation shall include a report scheduling all dampers with the test results.

Dampers intended to perform a smoke control function should be approved according to an internationally acceptable standard.

Damper dimensions may not exceed the tested and approved sizes, and may only be installed in the orientation and wall type tested, with the correct flow direction. The damper listing should include specifics about tested flow conditions and the maximum tested velocity stated to ensure closure under flow conditions.

5.7.6 Smoke Control Dampers

Automatic fire and smoke dampers shall be tested and comply with SANS 193 [17]. The damper and any installation frame shall be off the same fire resistance rating as the element of construction which it passes through.

5.8 FIRE EXTINGUISHERS

Fire extinguishers are to be located at positions close to potential fire risks and generally at a rate of 1/100 m^2 or 1/200 m^2, based on the level of risk. The fire extinguisher types that will be supplied are as follows:

- 9kg Dry Chemical Powder (DCP) fire extinguishers that shall be positioned in the majority of plant areas; and
- 5kg CO_2 (carbon dioxide) that will be positioned in electrical switchgear rooms, substations and control rooms.

Portable fire extinguishers shall comply with the requirements of SANS 1910 [43].

5.9 FIRE STATION

A fire station shall be provided for the power station. There shall be facilities for change rooms/showers/toilets, a workshop, storage, administrative duties and appliance room for the fire-fighting vehicle and the 2 000 litre trailer foam tank.

The appliance room shall be based on the requirements of SANS 10090 [48].

5.10 FIRE WATER SYSTEMS

5.10.1 Water Supplies

The water supply or supplies for fixed fire protection installations shall as a minimum be based on the fire scenario with the largest designed fire water demand taken from activation of the fixed suppression systems, plus the maximum hose stream demand of not less than two (2) hydrants for a minimum duration of two (2) hours. The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required.

Common tanks may be used for fire and other water services (i.e. use of water for floor washing) – provided that the minimum fire water storage requirements are always guaranteed and unnecessary starting of main fire water pumps is avoided.

Given the small volume of water required for wash down services in comparison to the fire protection system, the provisions of a separate pump associate with these facilities may be required if the static water pressure is inadequate. The flow rate and required pressure for these services should be separate from the pump duty and requirements of the fire protection system.

The volume of water usage required for these services supplementary to the fire protection system requirements should be calculated and added to the overall water storage requirements for the fire protection system to determine the overall tank size required.

When tanks are used they shall be connected to an automatic refilling system that shall be able to replenish the fire water requirement in a maximum of eight (8) hours. This requirement is not strictly required should “back-up” water supplies be available for fire protection.

The installation and construction of storage tanks shall be in accordance with the relevant Design Standards and sound engineering practice.

5.10.2 Fire-Fighting Water Reticulation System

In addition to the specific areas of the plant identified in this standard, the provision of fire suppression systems shall be determined by a person competent and registered in South Africa in fire technology.

Each fire suppression system shall be equipped with approved local alarm devices with audible and visual annunciation in the main control room and connected to the site wide fire detection and alarm network.

Sectionalising and damage control of the reticulation system shall be catered for.

The fire water range is designed to provide for ready access at sufficient head all over the power station site. The site water main shall typically be charged at high pressure – ranging around 7 to 10 bar. The use of pressure reducing valves is not recommended and alternative design solutions must be considered.

The source of water for floor washing, random availability or access to the reticulation system and also the pressure requirements make the fire range almost ideal for the purpose of floor washing. For this reason as well as purging of the fire range system with freshly produced water, the combination of fire water and floor washing reticulation system shall be considered. If these two systems are combined, the following must be prevented:

- Starting up main fire pumps to feed water for floor washing purposes.
- Pilfering; and damage of fire-fighting equipment such as fire hoses, branches and fittings by using them for floor washing purposes.

5.10.3 Fire Hydrants

Fire hydrants shall be supplied in the areas where hydrant protection is required, based on the fire risk analysis of the power station site.

Hydrants and hose reels shall be spaced according to SANS 10400-T [55], and in remote areas such as coal stock yards and overland conveyors, a spacing of 90 m to 150 m shall be allowed. The hydrants should be positioned such that at least one is within 40 m of the building or item of plant it is intended to protect.

Pipes feeding hydrants shall not be less than 100 NB. The flow rate for the fire hydrants is 20 l/s (1 200 l/min) and the standard requirement is the simultaneous flow of two hydrants. Where feed pressures only is required at the hydrant (the fire brigade is to provide boosting of systems), the system should be designed with the most remote hydrant having a pressure of 350kPa, as per Eskom minimum requirements.

Fire hydrants shall be supplied through 80 mm risers. Double outlet hydrants supplied through 100 mm risers are also acceptable where required.

High volume hydrants are allowed based on the requirements of the specific site. There is no reference to high volume hydrants in any of the South African standards, thus care must be taken in the specification of high volume hydrants.

The design shall conform to the standards referenced in SANS 10400-W [56]. All hydrant connections are standardized fittings throughout the station and readily available in the industry.

The typical fire hydrant specification is as follows:

- Inlet: 80 mm, Male BSP Thread.
- Fire Hydrant Outlet: 65 mm Female Instantaneous Outlet with double opposing ‘lugs’.
- Body Material: Cast Iron or Bronze.
- Spindle Material: Stainless Steel.
- Spindle Square Size: 16 mm (to SANS 1128 [34] Specification).
- Working Pressure: Seat tested to 16 bar

Diaphragm-type hydrant valves are also acceptable as they are maintenance free, with no spindle to collect dust and no gland leakages.

If a site has existing hydrants, any addition or replacement should be made with the same type of hydrant, only if the current hydrant type is not problematic.

The fire hydrant and hose reel system shall be designed in accordance with SANS 1128 [34] and SANS 10400-W [56].

Fire hydrants and/or hose reels shall be provided for manual fire protection, and located such that access to them will not be impeded by fire.

5.10.4 Hose Reels

Fire hose reels shall be located in accordance with SANS 10400-T [55] requirements at a rate of 1/500m^2 of floor, or part thereof.

As the buildings on site and other services may not be conducive to effective location of fire hose reels, locations may be adjusted to provide the best coverage based on the 30m length of hose associated with hose reels. Fire hose reels are to comply with all requirements of the latest edition of SANS 543 [23].

5.10.5 Fire Water Pumps

The fire water pumps are required to meet the fire flow requirements determined by the largest fire area demand. A sufficient number of pumps shall be provided to ensure 100% redundancy in fire water pump capacity.

The preferred installation is:

- 100% pumping capacity by SANS/ASIB approved electrical fire water pumps; and
- 100% pumping capacity by SANS/ASIB approved diesel-driven fire water pumps.

The combination can be varied based on size and lead time of pumps, as long as a 100% redundancy in pumping capacity is supplied.

Maintaining the pressure in the fire water piping systems can be achieved either by pressure maintaining pump(s) (jockey pumps) or with head tank pressure.

Fire pump installations shall conform to sound fire protection engineering practice. The fire pumps shall be automatic starting with manual shutdown. The manual shutdown shall be at the pump controllers only. The selection of pump drivers shall be at the discretion of the designers – provided that fire pumps shall not be subject to a common failure, mechanical or electrical.

A diesel pump driver as well as the diesel tank supply shall be provided with automatic fire suppression systems.

The electric and diesel pumps and pump set drive controllers shall conform to the requirements of SANS 10287 [54].

The following controls, indications, alarms and trips listed in **Table 6** shall be functional in the fire water pump house:

Table 6: Fire Water Pump House Controls, Indications, Alarms and Trips

Controls, Indications, Alarms and Trips	Electrical Fire Pump Set	Diesel Fire Pump Set
Controls	• Stop/start buttons for each pump • Alarm Reset.	• Stop/start buttons for each pump • Alarm Reset.
Indication on control panel	• Fire alarm activated • Failure of pump to start • Pump running • Pump trip	• Fire alarm activated • Failure of pump to start • Pump running • Low oil pressure • High oil pressure
Other Indications	• Pump suction pressure	• Pump suction pressure

Controls, Indications, Alarms and Trips	**Electrical Fire Pump Set**	**Diesel Fire Pump Set**
	• Pump discharge pressure • System Pressure • Flow switch indications	• Pump discharge pressure • System pressure • Flow switch indications • Diesel tank level indication
Alarms	• Fire alarm • Failure of pump to start (pump failure) • Pump running • Power available • Power failure (to the main electrical supply or of any one phase only) • Failure of the control circuit (from the end of the control circuit)	• Fire alarm • Power failure (of the electrical supply to the battery charger) • Failure of pump to start • Pump running • Low oil pressure • Failure of the battery charger (from both charger outputs in parallel) • Failure of the control circuit (from the end of the control circuit)
Trips	1. The pump shall not have any automatic stopping devices	2. The pump shall not have any automatic stopping devices

The following controls, indications, alarms and trips indicated in **Table 7** shall be functional in the control room:

Table 7: Control Room Controls, Indications, Alarms and Trips

Controls, Indications, Alarms and Trips	**Electrical Fire Pump Set**	**Diesel Fire Pump Set**
Controls	None	None
Indication on control panel	– Pump running – Mains failure (loss of power) – Alarm	– Pump running – Mains failure (loss of power) – Alarm
Alarms	– Pump running – Mains failure (loss of power) – Alarm	– Pump running – Mains failure (loss of power) – Alarm
Trips	The pump shall not have any automatic stopping devices	The pump shall not have any automatic stopping devices

Depended on the method used for maintaining pressure in the system, the jockey pump/header tank indications – such as “pump running” and “tank level” - must also be identified in full and indicated in the control room.

Pumps shall conform to the requirements in SANS 10287 [54], and in addition shall incorporate the following features:

- Electric Pump Churn Cooling: The electric pump should have a small bore (12.7 mm) pressure relief valve installed (set at 1 bar below churn pressure), to allow cooling water to flow through the pump casing during churn (no system flow) conditions. The lack of a cooling line will allow excessive temperatures to build up in the pump casing and could lead to cavitation damage to the pump impeller casing and/or over heating bearings.

- Diesel Pump Cooling Water Return: The diesel pump cooling water return line should be piped to drain (into a visible tonnage cup) or back to the tank (with a site gauge installed). The cooling water return line shall not pipe back to the suction side of the pump.
- Automatic Air Release Valves: Both pump (electrical and diesel) should be provided with an automatic air release valve, installed on top of the casing.

5.10.5.1 Fire Water Pump Standard Operating and Control Philosophy – Office Blocks

A typical office block fire protection system will consist of one set of pumps:

- 1x Jockey (or make-up) Pump;
- 1x Electrically driven fire water pump;
- 1x Diesel driven fire water pump.

(In some cases a separate hydrant pump or pumping system may be provided.)

The role of the Jockey Pump is to maintain the water pressure within the sprinkler system, to compensate for minor leaks.

The jockey pump must be sized so as to prevent this pump from maintaining one sprinkler in operation without the main fire pump starting. However it must also have a rated capacity of not less than any normal leakage rate. This is typical a flow not exceeding 40l/min.

Stopping and starting of the Jockey Pump is controlled from the pressure switch on the auto-start arrangement. See Figure 9: Typical layout of an auto-start arrangement for office blocks

In the event of sprinkler activation the Jockey Pump will be unable to maintain the system pressure and the set point of the second pressure switch on the auto-start arrangement will be reached causing the electrically driven fire water pump to start up.

If the electrically driven fire water pump fails to start the system pressure will continue to fall and the set point of the third pressure switch on the auto-start arrangement will be reached causing the diesel driven fire water pump to start up. As a final fail-safe a fourth pressure switch is provided on the auto-start arrangement and if its set point is reached will attempt to start the diesel driven fire water pump in the event that the third pressure switch has failed.

5.10.5.1.1 Starting on Pressure Drop

The jockey pump must start automatically when the pressure in the sprinkler installation has dropped to not less than 90 % of the normal pressure in the installation and must shut off automatically when the sprinkler installation pressure has reached either the jockey pump churning pressure, or 1200 kPa, whichever is lower.

The auto-starting arrangement pressure switches must be set to operate the electrically driven fire water pump (primary pump) when the pressure in the fire water main has fallen to a value not less than 80% of the pressure in the fire water main when the pump is churning or 100 kPa below duty pressure if this is above or equal to 80% of the churn pressure.

The diesel driven fire water pump (second pump) must be set to start when the pressure in the fire water main falls to a value of 100 kPa below the cut in pressure of the first pump. Two pressure switches must be provided to start the diesel driven fire water pump. The second pressure switch must be set to operate at not less than 20 kPa and not more than 50 kPa beneath the starting pressure of the primary switch.

All above is as per ASIB 11th Edition Rules [120].

5.10.5.1.2 Example

Consider a fire water pumping system in an office block with the following characteristics:

- System normal operating pressure – 600kPa;
- Jockey Pump churn pressure - 1000kPa;
- Jockey Pump duty pressure – 750kPa;
- Electrically driven fire water pump churn pressure – 700kPa;
- Electrically driven fire water pump duty pressure – 600kPa.

Following the criteria documented in section 5.10.5.2 we can deduce the following:

- The Jockey Pump must be set to start at equal to or more than 675kPa (90% x 750kPa)
- The Jockey Pump must be set to stop at 1000kPA (Its churn pressure which is less than 1200kPa)
- The electrically driven fire water pump must be set to start at 560kPa (80% x 700kPa and is above 500kPA (100 kPa below duty pressure)).
- The diesel driven fire water pump must have its first pressure switch set to start the pump at 460kPa (100kPa below the cut in pressure of the electrically driven fire water pump)
- The diesel driven fire water pump must have its second pressure switch set to start the pump at anywhere between 410kPa and 440kPa.

5.10.5.1.3 Typical layout of an auto-start arrangement for office blocks

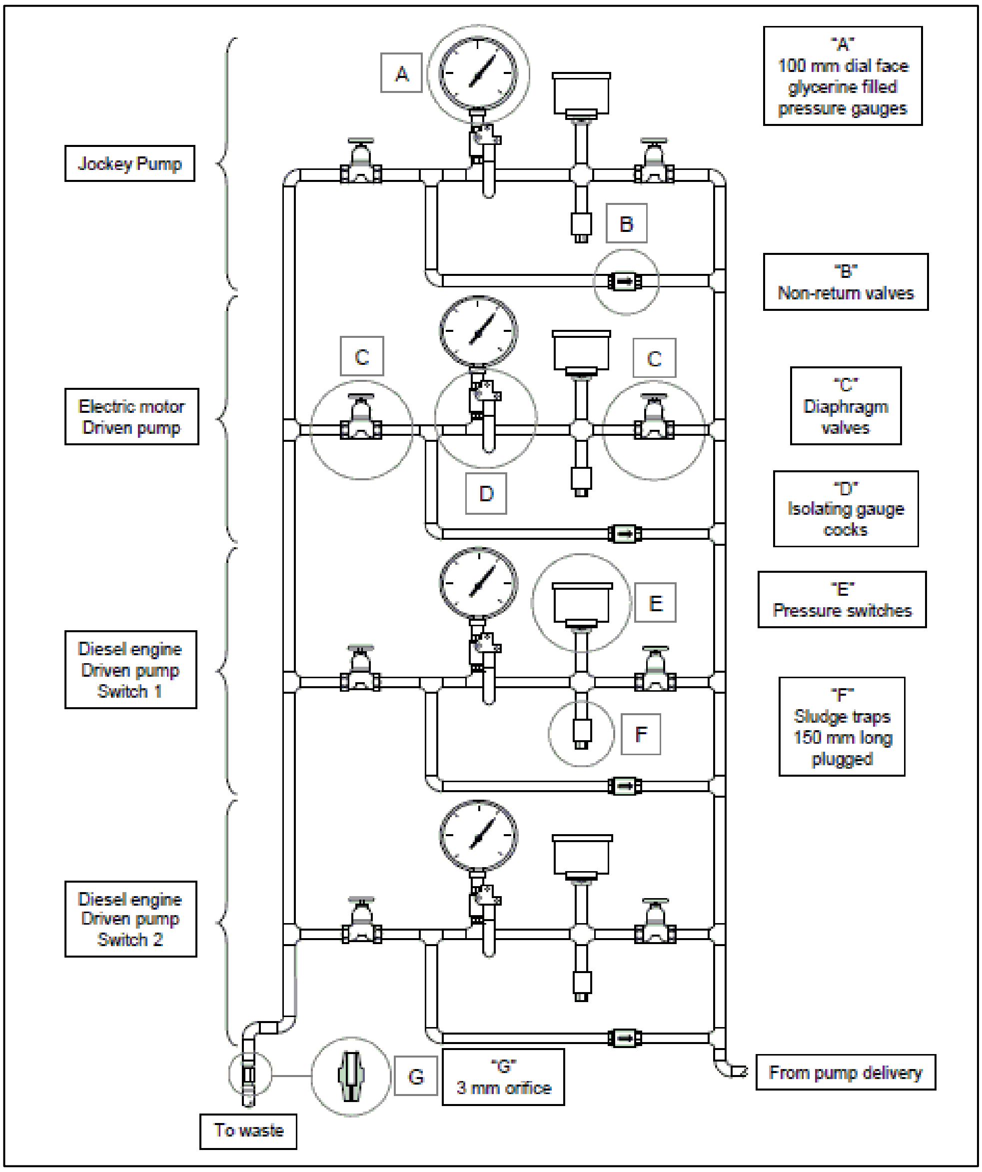


Figure 9: Typical layout of an auto-start arrangement for office blocks

5.10.5.2 Fire Water Pump Standard Operating and Control Philosophy – Power Stations

A typical modern power station fire protection system will consist of three sets of pumps:

- 2x (or more) Electrically driven fire water pumps and 2x (or more) Diesel driven fire water pumps;
- 3x Fire tank water pumps;
- 3x Boiler head tank pumps.

The four fire water pumps (each rated at 50% of worst case demand or each rated at 33% in the event of there being six fire water pumps) will typically be located in a fire pump house, with the electrically driven fire water pumps being in a separate, 2 hour fire rated, room to the diesel driven fire water pumps. These pumps will take suction from the fire main tank and discharge into the fire water ring main.

The three fire tank water pumps (two pumps operating and one on standby), will be typically located in the SSB (Service Station Building) and will take suction from filtered potable water tanks, which will usually be located in the water treatment area. The combination of these pumps will fill and maintain the water level of the fire main tank.

The three boiler head tank pumps (two pumps operating and one on standby), typically also located in the SSB, will take suction from the fire main tank and fill up six elevated fire head tanks; one fire head tank per unit boiler house. The elevated boiler head tanks will discharge into the auxiliary bay fire header and maintain the fire ring mains under a static pressure of around 900 kPa.

In the event of a small fire or minor hydrant usage, the water in the boiler head tanks will be used to satisfy the demand, with the boiler head tank pumps coming into operation to keep the boiler head tanks filled with water.

As the water demand required to fight the fire increases the boiler head tank pumps will no longer be able to keep the boiler head tanks filled and these tanks will start to empty. Once these tanks have emptied the pressure in the fire ring water ring main will start to drop and the set point of the first pressure switch on the auto-start arrangement will be reached causing the first electrically driven fire water pump to start up.

If the electrically driven fire water pump fails to start or if the system pressure continues to decrease the set point of the second pressure switch on the auto-start arrangement will be reached causing the second electrically driven fire water pump to start up. The pump controller may also be configured to start the second electrically driven fire water pump automatically between 5 and 10 seconds after the first electrically driven fire water pump starts on pressure drop. This is allowable in terms of NFPA 20 [64].

If the electrically driven fire water pumps fail to start the system pressure will continue to fall and the set point of the third pressure switch on the auto-start arrangement will be reached causing the first diesel driven fire water pump to start up. If the first diesel driven fire water pump fails to start or if the system pressure continues to decrease the set point of the fourth pressure switch on the auto-start arrangement will be reached causing the second diesel driven fire water pump to start up.

As a final fail-safe a fifth pressure switch is provided on the auto-start arrangement and if its set point is reached will attempt to start the diesel driven fire water pumps in the event that the third and fourth pressure switches have failed.

5.10.5.2.1 Starting on Pressure Drop

In terms of ASIB 11th Edition Rules [120], the jockey pump must start automatically when the pressure in the sprinkler installation has dropped to not less than 90 % of the normal pressure in the installation and must shut off automatically when the sprinkler installation pressure has reached either the jockey pump churning pressure, or 1200 kPa, whichever is lower. As the newer power station as well as the new build power stations do not use a jockey pump, instead relying on elevated fire head tanks in the boiler houses, a slightly modified method of determining the starting pressures of the fire water pumps is required.

The auto-starting arrangement pressure switches must be set to operate the electrically driven fire water pump (primary pump) when the pressure in the fire water main has fallen to a value not less than 80% of the pressure in the fire water main when the pump is churning or 100 kPa below duty pressure if this is above or equal to 80% of the churn pressure.

The subsequent pumps must be set to start when the pressure in the fire water main falls to a value of 100 kPa below the cut in pressure of the previous pump. Two pressure switches must be provided to start the last diesel driven fire water pump. The second pressure switch must be set to operate at not less than 20 kPa and not more than 50 kPa beneath the starting pressure of the primary switch.

5.10.5.2.2 Example

Consider a fire water pumping system in a power station with the following characteristics:

- System normal operating pressure – 1000kPa;
- Electrically driven fire water pump churn pressure – 1000kPa;
- Electrically driven fire water pump duty pressure – 960kPa.
- Elevated fire head tank low level – 900kPa
- Elevated fire head tank high level – 920kPa

Following the criteria documented in section 5.10.5.3 we can deduce the following:

- The first electrically driven fire water pump must be set to start at 860kPa (100 kPa below duty pressure) as this is higher than 800kPa (80% x 1000kPa). *It must be noted that the starting pressure of 860kPa is a theoretical amount and, depending on the elevated fire head tank characteristics, may have to be adjusted slightly during commissioning of the system.*
- The second electrically driven fire water pump must be set to start at 760kPa (100 kPa below the set point of the first pump)
- The first diesel driven fire water pump must have its pressure switch set to start the pump at 660kPa (100kPa below the cut in pressure of the second electrically driven fire water pump)
- The second diesel driven fire water pump must have its pressure switch set to start the pump at 560kPa (100kPa below the cut in pressure of the first diesel driven fire water pump)
- The diesel driven fire water pump must have its second pressure switch set to start the pump at anywhere between 510kPa and 540kPa.

5.10.5.2.3 Typical layout of an auto-start arrangement for power stations

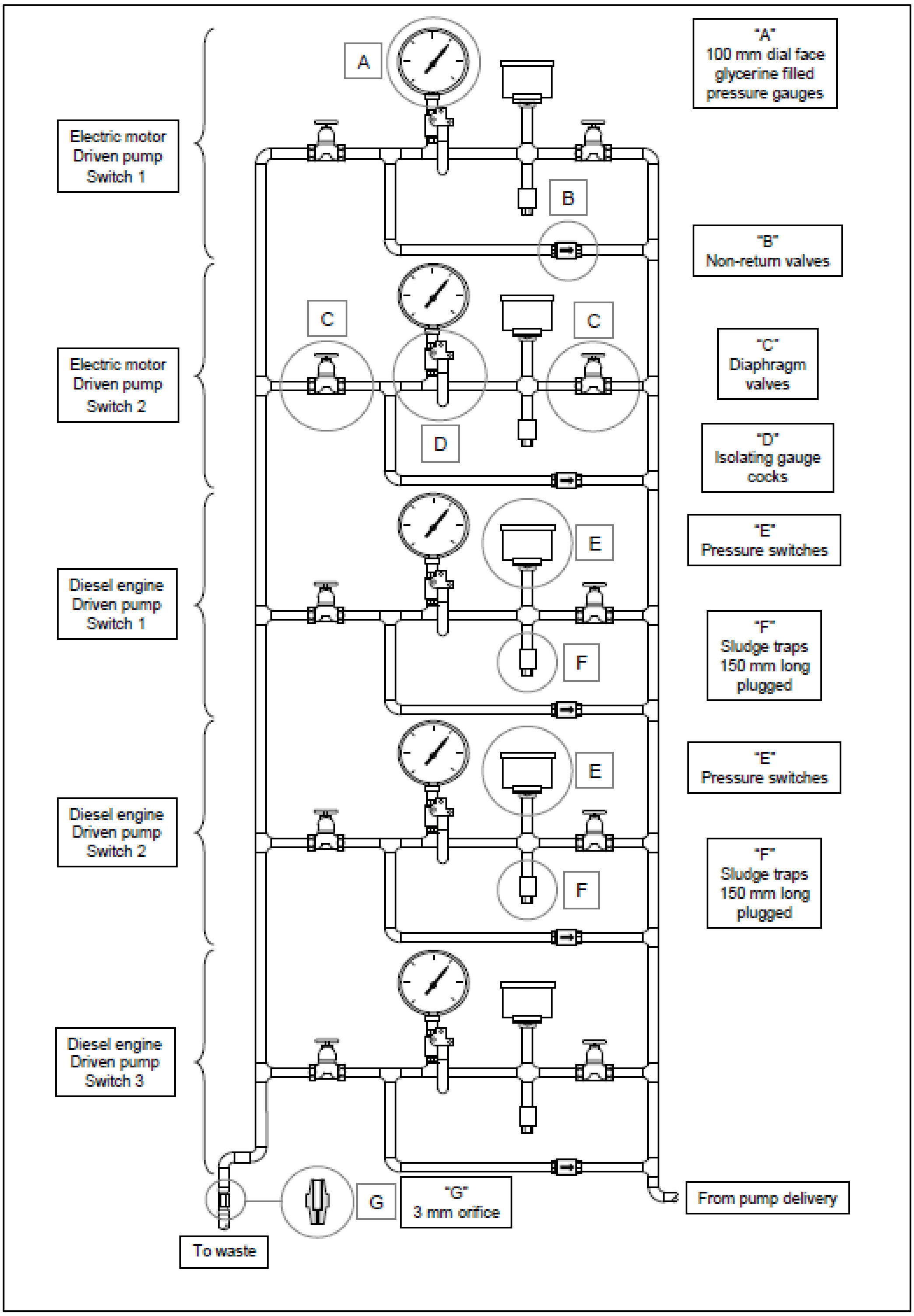


Figure 10: Typical layout of an auto-start arrangement for power stations

5.10.6 Actuation of Active Fire Protection Systems

Active fire protection systems shall be activated by mechanical, automatic means as far as practically possible. Any other method of activation shall be subject to the approval of Eskom.

This does not apply to Clean Agent Extinguishing systems.

5.10.7 Fixed Protection System Pipework & Associated Fittings and Fixtures

Any piping or equipment associated with the Fire Protection equipment shall be designed in accordance with SANS 10140-2 [52], and SANS 1091 [32] colour coding requirements as Table 1 for identifying hazards.

All fire protection equipment (i.e. pipework, equipment, and apparatus other than fire extinguishers) shall be painted in full with signal red in accordance with SANS 10140-2 [52].

Fire protection pipe networks shall be designed in accordance with sound pipe engineering practices and include all required fittings such as automatic air releases on high spots, drain points for flushing purposes etc.

5.10.7.1 Pipework

All the above ground pipelines for fire water systems shall be hot dipped galvanized steel specified in SANS 121 [14]. All pipes shall conform to SANS 62 [13] and SANS 719 [26]. All mild steel pipes and equipment shall be pressure rated according to the maximum working pressure in the system.

Pipework and fittings meeting the following requirements are deemed suitable for use in a water based suppression system:

- Steel pipes complying with the requirements of SANS 62-1 or SANS 62-2 [13] subject to a minimum wall thickness of 3.25mm. Any pipe used should be at least equivalent to medium grade black steel tube, and medium grade black steel tube when downstream of the installation control valve.
- Fabricated flanged steel pipe and fittings used upstream of the alarm valve above ground and that comply with the requirements of SANS 1476 [39].
- Shouldered-end pipes, fittings and couplings that comply with the requirements of SANS 815 [29].
- Black polyethylene pipes installed below ground and that comply with the requirements of SANS 533-1 or SANS 533-2 (or both) [17].
- Malleable cast iron fittings for fibre cement pressure pipes that comply with the requirements of SANS 14 [12].
- Cast iron fittings and couplings for shouldered-end pipes that comply with the requirements of SANS 815 [29].
- Fibre-cement pressure pipes that comply with the requirements of SANS 1223 [37].
- Bends in the pipework shall be kept to a minimum. Bends shall be of the swept long radius type having a radius of curvature of not less than one-and-a-half-times the diameter of the pipe.
- Tees shall be swept tees.

Any underground pipes should be protected against corrosion where necessary. Types of pipe that have previously been used and are suitable for below ground fire system mains are:

- PVC-M as specified in SANS 966-2 Part 2 [30].
- GRP as specified in SANS 1748-3 Part 3 [42].
- Type II Class 16 Black Polyethylene as specified in SANS 533-1 [22].

The decision as to what type of pipe to use for below grade fire protection pipelines rests with the designer and should be documented during the Fire Protection/Detection Assessment process confirming its suitability for its intended application.

All pipes up to 50NB shall be screwed and anything above 50NB shall be flanged.

5.10.7.2 Pipe Supports

All hangers and hanging material will be hot dipped galvanized to SANS 121 [14] after fabrication, and either welded or bolted on site. Site repairs and welding will be touched up with cold galvanizing in accordance with SANS 121 [14].

The fire protection system pipe supports shall be capable of supporting the loads of the system without exceeding the maximum permissible deflection. Pipes shall be positioned to maintain a clearance to any other fixed structure, except the members to which such pipes are clamped. Supports shall be designed in accordance with SANS 10287 [54].

Structural pipe supports are to be provided at intervals not exceeding 2.5 m for the piping up to 50 mm Nominal Bore (NB) and all other piping shall be supported at 4.5 m intervals.

5.10.7.3 Flanges & Bolting

All flanges supplied for the fire protection pipe reticulation system shall conform, as a minimum, to SANS 1123 [33].

The All flanges and bolts installed within a sprinkler system should:

- Flanges that comply with the requirements of SANS 1123 [33].
- Bolts and nuts that comply with the requirements of SANS 1700 [41].
- Mushroom head and countersunk head bolts that comply with the requirements of SANS 1143 [36].
- Shouldered and grooved couplings that comply with the requirements of SANS 815 [29]
- Be suitable for their application and use.

5.10.7.4 Valves

Locking facilities (40 mm Viro Pad Lock) shall be provided for all valves that need to be locked in the open position as per NFPA 850 [90], paragraph 4-3, 'Valve Supervision'. All manual isolation valves shall have an indication of the open or closed position so that valve position can be determined from a distance, or the shaft shall be permanently marked with the disk position.

All fixed fire protection control valves shall be of the 'non-clack' type valves. Diaphragm-type valves are the preferred type of control valve. Control valves of fixed fire protection systems shall have the typical wet/dry pilot control valve trim.

Gate valves shall be installed in the horizontal position to prevent the accumulation of debris in the valve seat. Geared butterfly valves are the preferred type of sectional isolation valve for fire water systems.

Fixed fire protection system control valves shall have weather-proof covering where they are situated outside.

The following listed valves are considered suitable for use on a water based suppression system:

- All valves with an LPC approval or as listed as approved in relevant FM data sheets and supporting information.
- Cast steel gate valves in accordance with SANS 191 [16].
- Water taps of the metallic type that complies with the requirements of SANS 226 [19].
- Copper alloy taps that comply with the requirements of SANS 776 [28].
- Cast iron gate valves that comply with the requirements of SANS 664 [24] or SANS 665 [25], and Section 5.2.3.1 (e) within SANS 10287 [54]. Not suitable for use on Hydro-Electric Power Stations.
- Control and safety valves that are LPC approved or FM approved or that comply with the requirements of SANS 198 [18].
- Be suitable for their application and use.

5.10.7.4.1 Control, Test, Drain, Flush, Ball, Float, Recycling, Pressure Reducing and Non-Return Valves

The following valves are considered suitable for fire water reticulation system and water based suppression systems:

- Control, test, drain, flush, and non-return valves that are SANS approved, LPC approved, or FM approved, and are deemed suitable for use dependant on the particular application.
- Where modified valves are identified during the design process they must comply as far as reasonably practicable with the relevant SANS stand.
- The spindle seal on a pump suction valve should be suited to operation under suction conditions so that it does not allow air to be drawn into the pump.
- Control and drain valves that control the flow of water to the suppression system shall be right handed.
- Valves as listed as suitable within SANS 10287 [54].
- Butterfly valves shall be of the gear-operated type.
- The pump suction stop valves shall be of the outside screw and yoke, (OS&Y) gate valve type
- Non-return valves should be suitably sized to operate under the working pressure of the installation.
- Valves that are LPC approved, or FM approved.
- Fire safe ball valves that comply with the requirements of SANS 1056-1 [31].
- Non-return valves, of the flanged and wafer type that comply with the requirements of SANS 1551-1 or SANS 1551-2 [40].
- Float valves that comply with the requirements of SANS 752 [27].
- Be suitable for their application and use.

5.10.7.5 Pressure Gauges

Glycerine filled pressure gauges fitted to a water based suppression system shall be suitable for use and be capable of taking measurements between 0kPa and 1600kPa, or 500kPa above the maximum working pressure of the proposed water supply, whichever is the higher.

The scale shall be sub-divided into units not exceeding:

- 20kPa, in the case of a maximum scale value up to and including 1000kPa.
- 50kPa, in the case of a maximum scale value exceeding 1000kPa, and up to and including 1600kPa.
- 100kPa in the case of a maximum scale value exceeding 1600kPa.
- Be suitable for their application and use.

5.10.7.6 Pressure and Flow Switches

Pressure switches and flow switches shall be located on every fixed fire protection system to allow for alarming in the control room when the fixed fire protection systems are actuated. Fire detection status monitoring of all pressure and flow switches is required where multiple branch pipes exist and are fed from one source of water supply.

Typically pressure switches are best suited for deluge systems and flow switched are best suited for sprinkler systems.

In addition level transducers and alarm devices should be provided to monitor the water levels within any storage tank and this level must be indicated in the control room.

5.10.7.7 Fasteners

Fasteners shall conform, as a minimum, to SANS 1700 [41], including the following:

- All fasteners used are metric fasteners.

- Each bolt head is fitted with a flat washer.
- Each nut is fitted with a flat washer.
- Each bolt length is sized so that two full threads are visible (minimum).
- No bolts are cut to the 'right' size.
- All fasteners are new.
- All fasteners are coated in an anti-seize compound before fastening.

5.10.7.8 Gaskets and Seals

Gaskets which will be used in the fixed fire protection system shall not contain any asbestos. All relevant gaskets shall be full-face pipe flange gaskets made from Aramid fibres bound with Nitrile Butadiene rubber 3mm thick.

5.10.8 Sprinkler Heads

Sprinkler heads shall conform, as a minimum to the following:

- Sprinklers must be of approved makes and types. Generally the Factory Mutual (FM) and Loss Prevention Certification Board (LPCB) are deemed to be an acceptable approving authority
- Sprinklers must not be altered in any respect nor have any type of ornamentation, coating applied or be painted other than by the manufacturer after leaving the manufacturers facilities.
- Sprinklers shall not be screwed into range pipes before range pipe erection and may only be installed once the pipework is secured in place.
- Only the manufacturers sprinkler wrench may be used to fit sprinklers to pipe work
- Sprinkler heads that have been in service may not be reused or relocated regardless of the circumstances. Once a sprinkler or a sprinkler pipe with sprinkler fitted to it is unscrewed from the fitting it shall be discarded.
- Where a sprinkler is contaminated by paint or any other substance that adheres to any part of the sprinkler, it must not be cleaned but shall be replaced with a new one.
- Sprinklers shall be installed with the sprinkler frame running parallel to the pipe in order to avoid pipe or frame shadow.
- Sprinkler heads shall not be intermixed. All sprinklers within any compartment at roof or ceiling level shall have identical operating characteristics inclusive of K-Factor, manufacturer, distribution patterns, orientation and thermal sensitivities. A compartment is defined as a room or area separated from any adjoining area with walls or partitions where a door lintel is at least 200 mm below the level of the sprinkler deflector.

5.10.8.1 Temperature Ratings

- Sprinklers are approved in nominal temperature ratings ranging from 57°C to 260°C.
- The temperature rating chosen shall be as close as possible to, but not less than, 30°C above the highest anticipated temperature conditions.
- For normal conditions in Southern Africa, a rating of 68°C or 79°C will be generally suitable for Ordinary Hazard occupancies.
- Under unventilated concealed spaces which includes ceiling or roof voids, it will be necessary to install sprinklers with a temperature rating between 93°C and 141°C.
- Unless otherwise stipulated, in High Hazard systems, 141°C sprinklers must be used on all High Hazard risks. This would typically include turbine protection systems as an example.

Table 8 has been adopted to distinguish sprinklers of different nominal temperature ratings:

Glass bulb types	Colour of bulbs

(°C)	
57	Orange
68	Red
79	Yellow
93	Green
141	Blue
182	Mauve
204/260	Black

Table 8: Fusible Bulb Colour Codes

5.11 INFORMATION DESIGN MANUAL

An information design manual is to be compiled, and shall verify that the fire protection features addressed in this standard have been met. This manual should form part of the fire risk profile called for as part of the Fire Risk Management programme for the business unit.

The manual shall list all fire protection features, i.e. active and passive, with explanatory statements as needed to identify location, type of system and design criteria. The manual shall also identify any deviations from this standard, and shall present alternatives for review. Justification for deviations shall show that an equivalent or better level of fire protection will be achieved. Deletion of a protective feature without compensating alternative protective measures will generally not be accepted, unless it is clearly demonstrated that the protective measures are not needed because of the design arrangement of the particular plant. A Rational Fire Engineered Design approach is required under such circumstances.

5.12 COMMISSIONING, INSPECTION, TESTING AND MAINTENANCE

On installation and commissioning, all fire protection systems and equipment shall be inspected and tested in accordance with the design and performance specifications. All results shall be documented and made available to operating staff.

Commissioning documents, including handover certificates shall be provided for all passive and active fire protection systems and equipment installed.

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

5.13 COMMISSIONING TESTS OF PIPEWORK AFTER INSTALLATION

The testing of pipelines detailed below is as per SANS 10287 [54], this may vary slightly dependant on the design code used.

All dry pipework in water-sensitive areas of the installation (such as computer areas) shall be pneumatically pressure tested to not less than 250 kPa.

Pipework shall be deemed to be satisfactory if the air test pressure is maintained for a period of at least 24 h without any additional input of air into the installation during that period.

All pipework not in water-sensitive areas shall be hydraulically tested to 1 500 kPa at the highest sprinkler, or to a maximum working pressure of 500 kPa above the working pressure of the installation, whichever is the higher.

Pipework shall be deemed to be satisfactory if the water test pressure is maintained for a period of not less than 1 hour without any additional input of water into the installation.

If any fault, such as permanent distortion, rupture or leakage, is disclosed by the hydraulic test, the fault shall be corrected and the test shall be repeated.

6. FIRE PROTECTION REQUIREMENTS FOR GENERAL AREAS

6.1 CONTROL ROOM, COMPUTER, I.T. SERVER AND COMMUNICATION ROOMS

6.1.1 General

Control Rooms, Computer Rooms, and Communication Rooms are the hub of a power plant where process is controlled and operated, whilst also monitoring environmental conditions critical to the safety of operatives. Server Rooms, although not critical for plant process control, are critical for providing I.T. services which ensure continued business productivity. The fire protection measures incorporated to protect operatives and to safe guard business productivity and continuity throughout these areas should reflect their overall importance.

Typically, where possible, these rooms should be separated from high risk areas, either through distance, or fire resistant separations.

Generally Control, Computer, Server and Communication Rooms shall also take into consideration the recommendation within SANS 246 [20].

6.1.2 Fixed Protection System

There are a number of suppression options available for these rooms, each coming with different hazards and associated risks, be it business continuity, potential property damage, or life safety.

The most appropriate fixed protection system installed within this area should take into consideration the hazards and associated risks during the Fire Protection/Detection Assessment process and document any decisions made in detail for future reference.

The systems suitable for inclusion within the Control Area, dependent upon evaluation of the impact to occupants and business continuity would be:

- Automatic Sprinkler system in accordance with NFPA 13 [61]
- Automatic Water Mist system in accordance with NFPA 750 [89]
- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (sealed rooms – inert gases)

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of any gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation / air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system.

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

Consideration should be made to the on-going use of equipment and the ability for the power plant to continue to operate should critical systems be lost due to fire. Each area and item of equipment should be evaluated within these rooms (i.e. within the rooms, beneath raised floors where critical systems and cabling is contained, critical items of equipment, critical power distribution and control boards) with an appropriate form of protection provided.

For example critical distribution and control boards may be protected via a combination of in-cabinet aspirating smoke detection which could trigger an in-cabinet gas suppression system. Also, as a minimum, an automatic fire suppression system shall be provided for areas beneath raised floors which have a clear height exceeding 800mm and total area of more than 300m^2.

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [4] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings shall take into consideration the detail provided within Section 5.10.7 of this Standard.

Any gaseous system provided should be designed in accordance with SANS 14520 Part 1 [57] and NFPA 2001 [93].

6.1.2.1.1 Water Supplies

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

6.1.2.1.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

6.1.2.2 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

6.1.2.3 Fire Resistant Separation Requirements

Fire areas shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities. Control, Computer, I.T Server and Communication Rooms shall be separated from all adjacent areas via a minimum of two (2) hours fire resistant construction.

Fire separations should typically have no openings other than:

- For closures such as door sets
- Penetrations complying with 6.1.2.4.

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

Fire barriers rated to provide a minimum of 2 hours fire resistance (both integrity an insulation rating) shall, as a minimum, be provided in the following areas:

- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.

Fire barriers shall be spaced at intervals that will prevent the spread of fire to more than one boiler/turbine generator building or to any other adjacent area.

Fire area boundaries shall be determined based on consideration of the details provided within Section 5.3.1 of this standard.

6.1.2.4 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

6.1.2.5 Control Room Smoke Vent

Consideration should be made to providing the Control Room with a means for venting smoke from the area. The aim of a smoke ventilation system is typically to provide conditions that are safe for occupants to evacuate from. Given the nature of the operation of the control room and its importance to business continuity the implementation of a smoke ventilation system should be carefully considered, with the goals and system requirements carefully documented (i.e. is the system required to maintain smoke free conditions such that the control room can continue to operate, is the system to be designed to maintain tenable conditions as detailed within international guidance based on visibility and toxicity limits to assist with escape etc.). The design of the system, and the competency of any staff member with design responsibility, should be carefully considered.

(British Standard BS7974 Application of fire safety engineering principles to the design of buildings – Code of Practice and its supporting Published Documents PD7974 Parts 0 to 7, and BS EN 12101 Parts 2 and 3 provide guidance on the approach to be undertaken for fire engineered solutions, and the design of mechanically assisted, or natural, smoke and heat ventilation systems.)

Care should be taken when designing any system to ensure discharge points do not affect walkways or escape routes in other areas.

6.1.2.6 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer’s recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.2 CABLE CONCENTRATIONS, CABLE SPREADING ROOMS AND CABLE TUNNELS

6.2.1 General

Given the large volume of cables typically located within cable spreading rooms and cable tunnels, the impact of a fire within these areas, with the potential to impact upon numerous other areas and items of equipment, protection from fire for these areas should not be overlooked. The down time and interruption to power generation facilities could be significant, with long delays expected where re-cabling is required.

Where practicable, cable trays shall be routed away from fire exposure or hazards. Where it is not practical to re-route the cable routes they should be protected from exposure to fire and heat.

Where cable trays are subject to oil spills, the trays shall be designed to either prevent the spread of oil spill fires, or prevent the accumulation of oil across the trays (i.e. provision of covers to the cable trays, with a means for catching and storing any oil spill below the tray). Should a drip / tray store be provided below the cable tray, consideration should be made as part of the maintenance regime to cleaning these areas on a regular basis.

Typically under-floor and concealed cable spreading areas which have a height of more than 800mm and a total floor area exceeding 300m^2 shall be provided with a fire detection system. The Fire Detection and Life Safety Design Standard [5] shall be referred to when selecting the most appropriate fire detection system for the area.

6.2.2 Cable Tunnels – Cable Requirements

Given the remote nature of cable tunnels and the difficulties posed when attempting to access and conduct fire-fighting operations within these areas, careful consideration should be made to the choice of cable used within the tunnels.

In the first instance the use of wiring systems designed to maintain circuit integrity under fire conditions should be designed (i.e. non-halogenated cables). This limits the impact upon the cables from heat exposure, designs resilience into the system to assist with business continuity, and limits the amount of residue and products emitted should the cables be exposed to excessive heat. This will help assist with any fire fighter operations in that access to the area will not be via smoke logged areas.

Should the use of non-halogenated cables not be possible additional protection measures should be provided. Where possible, and cost effective, both non-halogenated cables and suppression should be provided to these areas.

6.2.3 Fixed Protection System

There are a number of suppression systems available for use within the Cable Spreading Room and Cable Tunnels, each coming with different hazards and associated risks, be it business continuity, potential property damage, or life safety.

The most appropriate fixed protection system installed within this area should take into consideration the hazards and associated risks during the Fire Protection/Detection Assessment process and document any decisions made in detail for future reference. Typically cable tunnels are unoccupied spaces, with minimal access required for maintenance and repair. Given the infrequent access requirements within these areas any suppression system provided should be for asset protection only, and should not be over designed as a life safety system.

The systems suitable for inclusion within the Cable Spreading Room and Cable Tunnels would be:

- Automatic sprinkler system in accordance with NFPA 13 [61].
  Automatic sprinkler systems should be designed for a minimum density of 12.2mm/min over 232m^2, or the most remote 30m of cable tunnel up to an area of 232m^2.
- Automatic Water Deluge system in accordance with NFPA 15 [62].
- Automatic Water Mist system in accordance with NFPA 750 [85].
- Foam Suppression or protection system (medium/high expansion) in accordance with NFPA 11 [59].
- Clean Agent Fire Extinguishing systems
- Aerosol fire extinguishing systems in accordance with NFPA 2010 [94].

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of any gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation / air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system.

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7of this standard.

Any gaseous system provided should be designed in accordance with NFPA 2001 [93] and SANS 14520 Part 1 [57].

6.2.4 Fire Water System

6.2.4.1 Water Supplies

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

6.2.4.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

6.2.4.3 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

6.2.5 Fire Resistance Separation Requirements

Fire areas shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities. Any cable tunnels or cable spreading rooms shall be separated from **all** adjacent areas via a minimum of two (2) hours fire resistant construction.

Fire separations should typically have no openings other than:

- For closures such as door sets
- Penetrations complying with 6.2.6

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

Fire barriers rated to provide a minimum of 2 hours fire resistance (both integrity an insulation rating) shall, as a minimum, be provided in the following areas:

- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.

Fire barriers shall be spaced at intervals that will prevent the spread of fire to more than one boiler/turbine generator building or to any other adjacent area.

Fire area boundaries shall be determined based on consideration of the details provided within Section 5.3.1 of this standard.

6.2.6 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

6.2.7 Smoke Ventilation

Consideration should be made to providing the Cable Spreading Room and Cable Tunnels with a means for venting smoke from the area. The aim of a smoke ventilation system is typically to provide conditions that are safe for occupants to evacuate from. Given the cable tunnels and cable spreading rooms are typically unoccupied any smoke ventilation system will be purely for clearing the affected area of smoke, and not one for maintaining tenable conditions for operatives. It may be possible to combine the smoke extract system with the day to day ventilation system provided within this area. Careful consideration to the rating of the extract fan should be made in this instance as a fan typically chosen for day to day ventilation will not be able to operate under fire conditions given the increased smoke temperatures to be extracted. The design of the system, and the competency of any staff member with design responsibility, should be carefully considered.

SANS 10400 Part T – Fire Protection [55] and BS EN 12101 Parts 2 [114] and 3 [115] provide guidance on the design of mechanically assisted or natural smoke and heat ventilation systems.

Care should be taken when designing any system to ensure discharge points do not affect walkways or escape routes in other areas.

6.2.8 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.3 SWITCHGEAR & RELAY ROOMS

6.3.1 Fixed Protection System

Should a switchgear or relay room be identified as critical to the continuous operation of the power plant the installation of a gaseous suppression system should be considered. During the Fire Protection/Detection Assessment process the most appropriate form of gaseous suppression, taking into consideration the geometry and construction of the room should be taken into consideration.

- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (sealed rooms – inert gases)

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of any gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation / air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system.

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [4] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

Any gaseous system provided should be designed in accordance with SANS 14520 Part 1 [57] and NFPA 2001 [93].

Where gas suppression systems are installed, drains and appropriate dampers shall be provided with adequate seals, or the gas suppression system shall be sized to compensate for the loss of suppression agent through the drains.

6.3.2 Fire Resistance Separation Requirements

Switchgear and Relay rooms shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities. Switchgear and Relay Rooms shall be separated from all adjacent areas via a minimum of two (2) hours fire resistant construction.

Fire separations should typically have no openings other than:

- For closures such as door sets.
- Penetrations complying with 6.3.3.

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

Fire barriers rated to provide a minimum of 2 hours fire resistance (both integrity an insulation rating) shall, as a minimum, be provided in the following areas:

- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.
- Fire barriers shall be spaced at intervals that will prevent the spread of fire to more than one boiler/turbine generator building or to any other adjacent area. The intervals are to be determined as part of the Fire Protection / Detection Assessment process.

Fire area boundaries shall be determined based on consideration of the details provided within Section 5.3.1 of this standard.

6.3.3 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

6.3.4 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.4 OIL COOLED CIRCUIT BREAKERS

Typically oil filled circuit breakers should be located where practicable outdoors and shall be separated from adjacent areas via distance as detailed within Section 4.

Where it is not possible to provide this level of separation by distance, fire rated construction shall be provided to physically separate areas. The material or fire barrier used to separate the areas shall be rated to provide three (3) hours fire resistant separation.

6.5 BATTERY ROOMS

6.5.1 Fixed Protection System

Should a Battery Storage Room be identified as critical to the continuous operation of the power plant the installation of a gaseous suppression system should be considered. During the Fire Protection/Detection Assessment process the most appropriate form of gaseous suppression, taking into consideration the geometry and construction of the room should be taken into consideration.

- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (sealed rooms – inert gases)

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of any gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation / air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system.

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [4] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

Any gaseous system provided should be designed in accordance with SANS 14520 Part 1 [57] and NFPA 2001 [93].

Where gas suppression systems are installed, drains and appropriate dampers shall be provided with adequate seals, or the gas suppression system shall be sized to compensate for the loss of suppression agent through the drains.

6.5.2 Fire Resistance Separation Requirements

Battery Rooms shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities. Battery Rooms shall be separated from all adjacent areas via a minimum of two (2) hours fire resistant construction.

Fire separations should typically have no openings other than:

- For closures such as door sets.
- Penetrations complying with 6.5.3.

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.

- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

Fire barriers rated to provide a minimum of 2 hours fire resistance (both integrity an insulation rating) shall, as a minimum, be provided in the following areas:

- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.
- Fire barriers shall be spaced at intervals that will prevent the spread of fire to more than one boiler/turbine generator building or to any other adjacent area.

Fire area boundaries shall be determined based on consideration of the details provided within Section 5.3.1 of this standard.

6.5.3 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

6.5.4 Battery Room Ventilation

Battery Rooms should be provided with ventilation to ensure the hydrogen content within the battery room is limited to a concentration of 0.8% percent by volume. SANS 10108 [49] provides details for sizing of the ventilation system.

Hydrogen gas that is mechanically exhausted from battery rooms shall be discharged to a safe location and preferably, directly to the outside of the power station building.

The installation of fire dampers in any ventilation exhaust duct from a battery room is not recommended.

Any exhaust duct, which leads through a fire barrier or fire resistant separation, shall be protected throughout its length by a material having a fire resistance rating equal to the barriers penetrated.

Exhaust air fans shall be interlocked with a battery charger(s) in order to prevent equalize charging of batteries when the exhaust fans are not operating.

6.5.5 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.6 SUB STATION & SWITCHYARDS

6.6.1 General

As part of the Fire Protection/Detection Assessment process the necessity to determine whether Sub-stations and any associated switchyard to be a critical service is required.

A sub-station area is typically deemed critical where a power outage may impact upon the safety of operatives elsewhere in the power plant, or whether there is the potential for interruption to the power plant operation, resulting in significant down time or delays.

The following measures should be taken into consideration for a sub-station and switchyard area.

6.6.2 Fixed Protection System

Should a Sub-station be identified as critical to the continuous operation of the power plant the installation of a gaseous suppression system should be considered. During the Fire Protection/Detection Assessment process the most appropriate form of gaseous suppression, taking into consideration the geometry and construction of the room:

- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (sealed rooms – inert gases)
- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (unsealed rooms CO_2)

Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of any gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation / air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system.

(Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [4] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

Any gaseous system provided should be designed in accordance with SANS 14520 Part 1 [57] and NFPA 2001 [93].

Where gas suppression systems are installed, drains and appropriate dampers shall be provided with adequate seals, or the gas suppression system shall be sized to compensate for the loss of suppression agent through the drains.

6.6.3 Fire Water Systems

6.6.3.1 Water Supplies

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required (refer to Section 6.6.3.2 for further detail).

6.6.3.2 Fire Service Facilities – Fire Hydrant & Hose Reel Systems

The number and location of fire hydrants and hose reels to the sub-station and associated switchyard should be determined during the Fire Protection/Detection Assessment process. The provision of such systems will provide a means for fighting any fire within these areas. It will allow remote fire-fighting operations to be carried out, allowing cooling and damping down of facilities at a safe distance.

Where fire hydrants are provided, it is recommended, in tandem with the Eskom emergency response procedures, that flat fire hoses and suitable nozzles for the hoses are provided adjacent the area to be protected in a dedicated, signed red box for fire fighter/Eskom Fire Response Team use.

All hydrant connections are to be standardized fittings throughout the station, with replacements readily available in the South African industry.

Fire hydrants and hose reels shall be located at intervals of 60 m and shall be supplied through 80 mm risers. The hydrants should be positioned such that at least one is within 40m of the building or item of plant it is intended to protect.

The fire hydrant and hose reel system shall be designed in accordance with SANS 1128 [34] with flow rate requirements taken from SANS 10400-T [55].

Fire hydrants and/or hose reels shall be provided for manual fire protection, and located such that access to them will not be impeded by fire.

6.6.3.3 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

6.6.3.4 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

6.6.4 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.7 TRANSFORMERS

6.7.1 Outdoor Oil Insulated Transformers

6.7.1.1 General

Typically transformers and their associated equipment are separated from adjacent areas, buildings, and equipment by a number of different medium. The following is a list of measures that could be incorporated, listed in order of preference. The most appropriate method for protecting the transformers and any other surrounding equipment should be determined during the Fire Protection/Detection Assessment process:

1) Provide adequate separation distance between the transformers and adjacent areas to control the effects of fire on either location. Section 4 of this report provides detail on the separating distances to be afforded between the transformer and all adjacent areas
2) Provide fire barriers between the transformer and any adjacent area where the separation distances detailed within Section 4 cannot be met. Typically this separation should be constructed to provide a minimum of two (2) hours fire resistant separation. Should a suppression system be provided it may be possible to reduce this level of separation to one (1) hour, this should however be evaluated as part of the Fire Protection/Detection Assessment process to determine whether the hazard and associated risk of a pool fire is sufficiently reduced by the introduction of a suppression system.
3) Carry out a Rational Fire Engineered Design assessment on the area in question to determine whether any other method of protection could be provided in lieu of Options 1 and 2 above.

6.7.1.2 Separating Distance

6.7.1.2.1 General

Determining the type of physical separation to be used should be based on the consideration of the following:

- Type and quantity of oil in the transformer – the greater the storage requirements the greater the protection measures to be incorporated.
- Size of a possible oil spill – surface area and depth.
- Type of construction adjacent to the structure, and the separating distance afforded.
- Power rating of the transformer.
- Fire suppression system provided.
- Type of electrical protective relaying provided.

6.7.1.2.2 Without Firewall between Transformers

As a minimum the separating distance to be afforded between transformers and adjacent structures where separating fire walls are not provided should be:

- Oil Storage of less than 1890 litres per transformer - A separating distance of 1.5m shall be maintained between the transformer and any adjacent structure or item of equipment.
- Oil storage >1890 litres and <18925 litres per transformer – A separating distance of 7.6m shall be maintained between the transformer and any adjacent structure or item of equipment.
- Oil storage >18925 litres per transformer – A separating distance of 15m shall be maintained between the transformer and any adjacent structure or item of equipment.

Further detail can be found within Section 4 on separation distances required, which have been determined on a DtS or rational design approach. Section 4 should be consulted in tandem within the detail above, and evaluated as part of the Fire Protection/Detection Assessment process to determine the most suitable separation distance to be applied.

6.7.1.2.3 With Firewall between Transformers

Section 4 of this document provides further detail on the firewall requirements to be provided to separate transformers from adjacent areas where the separating distances detailed within Section 4 cannot be met.

6.7.1.3 Fixed Protection System

During the Fire Protection/Detection Assessment process, where separating distances meeting the requirements of Section 4 cannot be met, the installation of a water deluge system should be considered for the transformer area, its associated equipment, and the oil spill area (bund) constructed around the transformer.

The introduction of a water deluge system will reduce the intensity of any oil pool fire, potentially allowing a reduction in the rating of any firewall or barrier constructed to separate the transformer from any adjacent structure. Any Automatic Water Deluge system, with high velocity nozzles, shall be designed in accordance with NFPA 15 [62].

The introduction of a foam suppression system will reduce the intensity of any oil pool fire, potentially allowing a reduction in the rating of any firewall or barrier constructed to separate the transformer from any adjacent structure. The foam will effectively provide a blanket over the flammable or combustible liquid, restricting air flow to any fire, whilst also cooling the fuel. Any foam suppression or protection system should be designed in accordance with NFPA 11 [59].

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

6.7.1.4 Water Supplies

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required (refer to Section 6.7.1.7 for further detail).

6.7.1.5 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

6.7.1.6 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

6.7.1.7 Fire Service Facilities – Fire Hydrant & Hose Reel Systems

During the Fire Protection/Detection Assessment process consideration should be made to providing fire hydrants within the vicinity of any transformer installation where the separation distance identified within Section 4 of this document cannot be met. The provision of such systems will provide a means for fighting any fire within these areas in addition to any other measures incorporated into the design. It will allow remote fire-fighting operations to be carried out, allowing cooling and damping down of facilities at a safe distance should it be required to protect adjacent areas.

Where fire hydrants are provided, it is recommended, in tandem with the Eskom emergency response procedures, that flat fire hoses and suitable nozzles for the hoses are provided adjacent the area to be protected in a dedicated, signed red box for fire fighter/Eskom Fire Response Team use.

All hydrant connections are to be standardized fittings throughout the station, with replacements readily available in the South African industry.

Fire hydrants and hose reels shall be located at intervals of 60 m in the general plant areas and shall be supplied through 80 mm risers. Double outlet hydrants supplied through 100mm risers are also acceptable where required. The hydrants should be positioned such that at least one is within 40m of the building or item of plant it is intended to protect.

The fire hydrant and hose reel system shall be designed in accordance with SANS 1128 [34] with flow rate requirements taken from SANS 10400-T [55].

Fire hydrants and/or hose reels shall be provided for manual fire protection, and located such that access to them will not be impeded by fire.

6.7.1.8 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.7.2 Indoor Oil Insulated Transformers

6.7.2.1 General

Where possible any new transformers located indoors shall be a dry-type transformer (i.e. no liquids used to cool the transformer). Where it is not possible to provide a dry type transformer the following protection measures should be considered as part of the Fire Protection/Detection Assessment process.

6.7.2.2 Fire Separations

Where indoor oil insulated transformers are provided the following separation requirements should be provided as a minimum:

- Where the oil capacity of the transformer exceeds 379 litres and is installed indoors it should be separated from all other areas via fire resistant construction or barriers rated to provide three (3) hours protection.
- Where a transformer has a rating greater than 35kV and is insulated with less flammable liquid, or non-flammable liquids, it should be separated from adjacent areas via fire resistant construction or barriers rated to provide three (3) hours protection.

Further detail can be found within Section 4 on separation distances required, which have been determined on a DtS or rational design approach. Section 4 should be consulted in tandem within the detail above, and evaluated as part of the Fire Protection/Detection Assessment process to determine the most suitable separation distance to be applied. Should a suppression system be provided it may be possible to reduce this level of separation to one (1) hour, this should however be evaluated as part of the Fire Protection/Detection Assessment process to determine whether the hazard and associated risk of a pool fire is sufficiently reduced by the introduction of a suppression system.

6.7.2.3 Fixed Protection System

Fixed water spray fire protection for the indoor transformer area and its associated storage shall be provided mainly for exposure protection and be in accordance with NFPA 13 [61] and 15 [62]. This allows for the fire area to be cooled, with adjacent areas to be pre-wet to control the build-up of heat, and possible spread of fire to adjacent areas.

A deluge or pre-action deluge system is typically to be provided to protect these areas, where a quick application of large quantities of water is required. During the Fire Protection/Detection Assessment process the fire protection designer shall determine the criteria to be controlled, and design the system accordingly. Typical this shall include all, or a number of the following:

- Cooling surrounding plant and equipment to prevent damage from fire exposure
- Extinguishing the fire
- A combination of one or all of the above

To limit false activation of the system the deluge system should be linked to the automatic fire detection and alarm system. The fire protection system designer should refer to the Fire Detection and Life Safety Design Standard [6] for this area and ensure adequate control is provided to the chosen system to operate the deluge system in the event of a fire.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

6.7.2.4 Fire Water Systems

6.7.2.4.1 Water Supplies

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required.

6.7.2.5 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

6.7.2.6 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

6.7.2.7 Shut-off, Control and Sensing Valves

It is preferred that fixed fire protection system be actuated by mechanical means as far as reasonably possible.

The control or release device for a pre-action deluge system may be a sprinkler head or suitable detector for the environment. The releasing device should be able to actuate the release of water, effectively charging the system. If a thermal releasing device is selected its operating temperature should be lower than that of the sprinkler head activation temperature. This ensures water is available at the point or area to be protected in the event of a fire. A second sprinkler head is required to activate (at a temperature point higher than the releasing device) before water is discharged over an affected area.

Alternatively, should protection against false alarms and unnecessary discharge of water not be required the deluge system may be actuated via the operation of a single sprinkler head which detects the fire, with the water discharged via a series of medium velocity or high velocity nozzles located to protect the area or equipment in question.

As required by NFPA 13 [61] the detection devices or systems are to be remotely monitored, which alerts operatives that either the release device or the suppression system has actuated. Remote monitoring of the system should typically be provided within the main Control Room, and also at the Main Fire Alarm Panel.

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [5] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

6.7.2.8 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer’s recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.7.3 Outdoor Oil Drainage Pits

6.7.3.1 General

Where outdoor oil filled transformers are provided adequate drainage is required to drain any oil spill away from any adjacent building, transformer, or other items of equipment. In addition to the measures detailed within Section 6.7.2.6 and FM Data Sheet 7-83 [98], the following should be considered and implicated where the Fire Protection/Detection Assessment process deems them to be applicable:

- Drainage should be provided to remove any oil spill away from the transformer
- The ground should be sloped to ensure oil naturally moves away from the source where leakage has occurred. Consideration should be made to the environmental impact of moving oil in this way, should it not be linked to a dedicated drainage system.
- Where dedicated drainage is not provided as part of a sloped system consideration should be made to providing curbed areas, bunds, or drainage pits to contain any oil spill.

6.7.3.2 Sizing of Oil Spill Pit Drainage

As a minimum, the following should be considered when designing any drainage system or associated facilities:

- Spill of the single largest container of flammable or combustible liquid in the area
- Containment for the maximum number of hoses required to operate when tackling an oil pit fire (the number of hoses and operation time should be determined during the Fire Protection/Detection Assessment process). NFPA 850 [90] recommends the drainage system should be designed to accommodate hose discharge for a minimum period of 10 minutes. This period of discharge should be evaluated and agreed for each specific area (but cannot be less than 10 minutes).
- Containment to accommodate the design discharge of any suppression system protecting the oil pit area. NFPA 850 [90] recommends the drainage system should be designed to accommodate hose discharge for a minimum period of 10 minutes. This period of discharge should be evaluated and agreed for each specific area during the Fire Protection/Detection Assessment process (but cannot be less than 10 minutes).
- The water discharged over the area Post-Fire to wash down the area and facilities (which may be greater than the quantity of water identified above).

6.8 EMERGENCY GENERATORS

6.8.1 General

The position and location of any standby emergency generator should be carefully considered during the Fire Protection/Detection Assessment process to ensure any ‘back up supply’ provided is not affected by a fire that would interrupt the normal supply to the plant.

Generators should typically be located such that they are adequately separated from adjacent areas, either through distance, or fire resistant separation.

Any fire resistant construction or barrier provided should be designed to provide separation for a minimum of two (2) hours.

6.8.2 Fixed Protection System

There are a number of suppression systems available for use within the Generator enclosure, each coming with different hazards and associated risks, be it business continuity, potential property damage, or life safety.

The most appropriate fixed protection system installed within this area should take into consideration the hazards and associated risks during the Fire Protection/Detection Assessment process and document any decisions made in detail for future reference. Typically Generator rooms are unoccupied spaces, with minimal access required for maintenance and repair. Given the infrequent access requirements within these areas any suppression system provided should be for asset protection only, and should not be over designed as a life safety system.

The systems suitable for inclusion within the Standby Generator room would be:

- Automatic Sprinkler system in accordance with NFPA 13 [61]
- Automatic Water Deluge system in accordance with NFPA 15 [62]
  Automatic sprinkler or water spray systems should be designed for a minimum density of 10.2mm/min over the fire area in question.
- Compressed air foam systems in accordance with NFPA 11 [59]
- Clean Agent Fire Extinguishing System in accordance with SANS 14520 Part 1 [57]

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of any gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation / air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system.

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

Where diesel storage in day tanks is located in the same fire areas as the diesel generators, they shall be provided with an automatic fire suppression system as detailed above. In addition, the tanks shall comply with SANS 10131-1 [50]. Typically the diesel day tank should be located in a separate fire compartment adjoining the generator room (separated via 60 minutes fire resistant construction) and shall be provided with the following:

- The diesel is to be stored in a sealed, steel storage tank with an incorporated bund facility limiting the risk of diesel spill within the area.
- There is to be no other equipment other than the diesel storage tank located within this room. Therefore there are no associated potential ignition risks within the area.
- Lighting provided within the tank room should be IP65 rated to restrict the ingress of moisture, potentially causing fault and providing ignition.
- A fusible link arrangement should be provided within each generator set to isolate the diesel fuel from the tank room ensuring diesel from the tank room will not fuel any fire.
- Low diesel level float, overfill and transfer pump alarms provided to highlight any problems.

The installation and operation of emergency generators driven by stationary combustion engines shall be in accordance with NFPA 37 [67].

6.8.3 Fire Water Systems

6.8.3.1.1 Water Supplies

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required.

6.8.3.1.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

6.8.3.1.3 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

6.8.4 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

6.9 STORE ROOMS, OFFICES & SHOPS

General store rooms (not associated with the storage of flammable or combustible liquids or materials), Offices and Shops are considered to be low risk areas. These areas should typically be protected in accordance with SANS 10400 [55].

During the Fire Protection/Detection Assessment process the provision of a suppression systems to these areas should they contain combustible or flammable materials, or are considered critical to plant operations.

A sprinkler system designed in accordance with NFPA 13 [61] would be the most appropriate form of suppression for these areas.

Should a fixed water based system be installed consideration to the water supplies and drainage requirements within these areas, outlined elsewhere within this document, will be required, as part of the Fire Protection / Detection Assessment process.

Pressure switches and flow switches shall be located on every fixed fire protection system to allow for alarming in the control room when the fixed fire protection systems are actuated. Fire detection status monitoring of flow switches is required where multiple branch pipes exist that are from one source of water supply.

In addition level transducers and alarm devices should be provided to monitor the water levels within any storage tank.

Typically these areas should be separated from adjacent areas via two (2) hours fire resistant construction or barriers. The requirement to separate should be evaluated during the Fire

Protection/Detection Assessment process to determine whether these rooms pose a risk to adjacent areas, or whether adjacent areas within their proximity pose a fire spread risk to the Store Rooms, Offices, or Shops.

6.10 WAREHOUSES

During the Fire Protection/Detection Assessment process where warehouses are considered to contain high-value equipment and combustible materials that are critical to power generation or that constitute a fire exposure to other important buildings, a suppression system should be provided.

A sprinkler system designed in accordance with NFPA 13 [61] would be the most appropriate form of suppression for these areas.

Should a fixed water based system be installed consideration to the water supplies and drainage requirements within these areas, outlined elsewhere within this document, will be required, as part of the Fire Protection/Detection Assessment process.

Pressure switches and flow switches shall be located on every fixed fire protection system to allow for alarming in the control room when the fixed fire protection systems are actuated. Fire detection status monitoring of flow switches is required where multiple branch pipes exist that are from one source of water supply.

In addition level transducers and alarm devices should be provided to monitor the water levels within any storage tank.

Typically these areas should be separated from adjacent areas via two (2) hours fire resistant construction or barriers. The requirement to separate should be evaluated during the Fire Protection/Detection Assessment process to determine whether the Warehouse poses a risk to adjacent areas, or whether adjacent areas within proximity of the Warehouse pose a fire spread risk.

6.11 DOCUMENT ARCHIVES

One of the most disastrous consequences of a fire is the loss of vital records, be they contracts, plans, specifications, computer tapes or personnel records. Records are almost always combustible and hence there is always a need to protect them protect against fire.

Archives may be protected by means of room flooding or in-cabinet gaseous fire suppression systems, but these are not an absolute requirement unless the Archive has been risk assessed as critical during the Fire Protection/Detection Assessment process.

Where provided, gaseous fire suppression systems must be provided with a means of turning them to manual actuation mode, and this mode must be selected, whenever persons are in attendance. When in manual actuation mode, it must be possible to actuate the system by means of one or more break-glass panels provided at suitable positions outside the archive. At least one such break-glass unit must be provided outside the main entrance door leading to the archive.

All archives shall be constructed of incombustible materials. Incombustible means “incapable of burning”, like steel, brick or mortar. So-called “flame retardant”, “fire retardant”, “flame resistant” or “fire resistant” materials do not meet the incombustibility requirements for a high-risk installation such as an archive. These merely have a higher ignition temperature, and retard fire spread, but will burn eventually and still add to the structural fire load (calorific value) of the building as a whole.

At least 2 x 9 kg hand-held DCP fire extinguishers should be provided at each archive, one inside the main entrance door and one outside. At archives where no fixed gaseous fire suppression system is installed, a further 2 x 9 kg DCP fire extinguishers must be provided inside the archive. Depending on the floor area of the archive, additional hand-held extinguishers may be required. Such fire extinguishers must be mounted in easily accessible positions.

6.12 FIRE PUMP ROOMS

6.12.1 General

The position and location of any Fire Pump Rooms should be carefully considered during the Fire Protection/Detection Assessment process to ensure the primary source pumping fire-fighting water supplies is not affected by a fire that would interrupt the normal supply to the plant.

Fire pump rooms should typically be located such that they are adequately separated from adjacent areas, either through distance, or fire resistant separation. While it is appreciated that the majority of existing power station have the fire pumps located adjacent to other plant and pumps, these affected power stations must consider relocation of the fire pumps to a separate fire pump house.

Any fire resistant construction or barrier provided should be designed to provide separation for a minimum of two (2) hours, with the fire stopping and intumescent coating of cables requirements of Sections 5.3.1 and 5.3.2 also taken into consideration.

6.12.2 Fixed Protection System

The most appropriate fixed protection system installed within this area should take into consideration the hazards and associated risks during the Fire Protection/Detection Assessment process and document any decisions made in detail for future reference. Typically Fire Pump Rooms are unoccupied spaces, with minimal access required for maintenance and repair. Given the infrequent access requirements within these areas any suppression system provided should be for asset protection only, and should not be over designed as a life safety system.

The systems suitable for inclusion within the Fire Pump Room (housing diesel driven fire water pumps only) would be:

- Automatic Sprinkler system in accordance with NFPA 13 [61]
- Automatic Water Deluge system in accordance with NFPA 15 [62]
- Foam-water sprinkler system in accordance with NFPA 16 [63]
- Compressed air foam systems in accordance with NFPA 11 [59]

Automatic sprinkler or water spray systems should be designed for a minimum density of 10.2mm/min over the fire area in question.

The guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

Should a fixed water based system be installed consideration to the water supplies and drainage requirements within these areas, outlined elsewhere within this document, will be required, as part of the Fire Protection/Detection Assessment process.

Pressure switches and flow switches shall be located on every fixed fire protection system to allow for alarming in the control room when the fixed fire protection systems are actuated. Fire detection status monitoring of flow switches is required where multiple branch pipes exist that are from one source of water supply.

In addition level transducers and alarm devices should be provided to monitor the water levels within any storage tank.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

6.13 MAINTENANCE SHOP

During the Fire Protection/Detection Assessment process where maintenance shops, or workshops, are considered to contain high-value tools and combustible materials that are critical to power generation or that constitute a fire exposure to other important buildings, a suppression system should be provided.

A sprinkler system designed in accordance with NFPA 13 [61] would be the most appropriate form of suppression for these areas.

Should a fixed water based system be installed consideration to the water supplies and drainage requirements within these areas, outlined elsewhere within this document, will be required, as part of the Fire Protection/Detection Assessment process.

Pressure switches and flow switches shall be located on every fixed fire protection system to allow for alarming in the control room when the fixed fire protection systems are actuated. Fire detection status monitoring of flow switches is required where multiple branch pipes exist that are from one source of water supply.

In addition level transducers and alarm devices should be provided to monitor the water levels within any storage tank.

Typically these areas should be separated from adjacent areas via two (2) hours fire resistant construction or barriers. The requirement to separate should be evaluated during the Fire Protection/Detection Assessment process to determine whether the maintenance shop poses a risk to adjacent areas, or whether adjacent areas within proximity of the maintenance shop pose a fire spread risk.

6.14 AIR COMPRESSORS

Where there is the possibility of large amounts of oil spill occurring from an air compressor the provision of a compressed air foam suppression system should be considered during the Fire Protection/Detection Assessment process. The inclusion of a foam suppression system will be dependent upon the quantity of oil stored within the compressor unit. Any compressed air foam suppression system provided should be designed in accordance with NFPA 11 [59].

Where the compressor is an oil free type, or it is deemed the quantities of oil do not pose a significant hazard (as determined during the Fire Protection/Detection Assessment process), an automatic sprinkler system, designed for a density of 10.2mm/min, providing coverage across the entire hazard area should be provided. The provision of sprinkler system designed in accordance with NFPA 13 [61] should be considered.

It may be determined that no suppression system is required for the area during the Fire Protection/Detection Assessment process as the hazard is limited. Should this be the case automatic detection should be provided, in accordance with the Fire Detection and Life Safety Design Standard [6], to alert operatives within the Main Control of a developing fire situation in the air compressor room.

6.15 OIL STORAGE AREAS

Internal clean or dirty oil storage areas should be protected if they contain combustible materials that present an exposure to surrounding areas that are critical to plant operations. This area generally represents the largest concentrated oil storage in the plant. The designer should consider, as a minimum, the installation of fixed automatic fire protection systems and the separation, ventilation, and drainage requirements.

6.16 DATA CENTRES

Fire protection systems for Data Centres are to comply with the following requirements:

- The National Building Regulations and Building Standards Act (Act 103 of 1977);
- Client specific requirements
- Uptime institute requirements
- System specific codes: SANS and NFPA

In order to achieve this, the following basic items must typically be provided:

Area	Fire protection system							
	Fire Hydrants	Sprinklers	Fire Hose Reels	Fire extinguishers	Gaseous Fire Suppression	Smoke Detection	Smoke Ventilation	Emergency Lighting
External	✓(1)	×	×	×	×	×	×	×
Offices	✓	×	✓	✓	×	✓	×(2)	✓
Data halls	×	×	×	✓	✓	✓	×(3)	✓
Service passages in data areas	×	×	✓	✓	✓	✓	×	✓
Electrical plant rooms	×	×	×	✓	✓	✓	×	✓
Transformer rooms (6)	×	×	×	✓	×	✓	×	✓
Diesel tank rooms	×	×(4)	✓	✓	×	✓	×(5)	✓
Generators (7)	×	×	✓	✓	×	✓	×	✓

Table 9: Data Centre Fire Protection Requirements

Notes:

1) The site around the data centre must be provided with fire hydrants, all areas must be within 60m reach of a fire hydrant.
2) Smoke ventilation is required should any room exceed 500m^2.
3) No smoke ventilation is required for the data halls, only post gaseous fire suppression system discharge venting.
4) Foam suppression system required due to the large amount of diesel usually stored onsite
5) Ventilation at 5 air changes per hour (i.e. the entire volume of air in the area is to be totally replaced five times per hour) to prevent flammable liquid build up, if diesel tanks are located indoors.

6) Transformer rooms must be equipped with dry resin type transformers and will not need to be provided with any automatic suppression, only smoke detection.
7) Generators and dynamic UPS's will not need to be provided with any type of automatic suppression, only smoke detection.

Portable fire extinguishers are designed to cope with fires of limited size and must be selected for the risk, it is also a requirement that all areas of the building be within 30m of a fire extinguisher.

All extinguishers are to be selected and installed in accordance with SANS 10400-T [55]and SANS 1910 [43] and the typical distribution of fire extinguishers within a Data Centre would be as follows:

Description	Type of extinguishers		
	Dry chemical powder (4.5kg)	Dry chemical powder (9kg)	CO2 (5kg)
Offices	✓	×	✓
Data areas	×	×	✓
Service passages in data areas	×	×	✓
Electrical plant rooms	×	×	✓
Transformer rooms	×	✓	✓
Diesel tank rooms	×	✓	×
Generators	×	✓	✓

Table 10: Data Centre Extinguisher Requirements

7. SPECIFIC GENERATING TECHNOLOGY AREA FIRE PROTECTION REQUIREMENTS

7.1 FOSSIL FUELED POWER STATIONS

7.1.1 Fuel Handling and Storage - Liquid Petroleum Gas (LPG)

7.1.1.1 General

The design and construction of any Liquefied Petroleum Gas (LPG) cylinder installations shall be in accordance with SANS 10087: Part I [44].

The design, erection and protection of any bulk LPG vessel, which has a water capacity in excess of 500litres, shall be in accordance with SANS 10087: Part III [45].

Note that the application of these standards is mandatory as they are called up in the Pressure Equipment Regulations of the OHSA.

During the Fire Protection/Detection Assessment process the risk of exposure to fire, or loss of equipment due to a fire in the equipment itself should be evaluated. Where the risk is considered to be low, or the equipment is sufficiently remote from other areas, or is not considered critical, the necessity to provide the following identified levels of protection may possibly be reduced.

7.1.1.2 Fixed Protection System

Fixed water spray fire protection for LPG installations and its storage shall be provided mainly for exposure protection and be in accordance with SANS 10087 [44], [45] (particularly for the minimum water flow requirements) with additional guidance given in NFPA 15 [62]. This allows for the areas that are on fire to be cooled, with adjacent areas to be pre-wet to control the build-up of heat, and possible spread of fire to adjacent areas.

Standard practice for fixed fire protection of gas cylinders or bulk tanks is a deluge water spray system. As detailed within SANS 10087 a minimum design flow rate of 10 L/min/m^2 over the whole surface of the storage vessel fire a minimum period of 60 minutes is required. The actual discharge time should be determined during the Fire Protection/Detection Assessment process. The deluge system utilises medium velocity deluge nozzles and the system is actuated by a wet pilot line with 68°C detector heads. If ambient freezing conditions are prevalent in the area a dry pilot line can be utilised for activation of the system.

A deluge or pre-action deluge system is typically to be provided to protect these areas, where a quick application of large quantities of water is required. During the Fire Protection/Detection Assessment process the fire protection designer shall determine the criteria to be controlled, and design the system accordingly.

Typical this shall include all, or a number of the following:

- Cooling a pressure vessel to prevent a boiling liquid expanding vapour explosion (BLEVE) occurring.
- Cooling surrounding plant and equipment to prevent damage from fire exposure
- Extinguishing the fire (once the gas supply has been isolated)
- A combination of one or all of the above

To limit false activation of the system the deluge system should be linked to the automatic fire detection and alarm system, or a suitable, alternative pre-action device (sprinkler head). The fire protection system designer should refer to the Fire Detection and Life Safety Design Standard [6] for this area and ensure adequate control is provided to the chosen system to operate the deluge system in the event of a fire.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.1.3 Fire Water Systems

7.1.1.3.1 Water Supplies

Consideration should be given to the requirements The water supply or supplies for fixed fire protection installations shall as a minimum be based on the fire scenario with the largest designed fire water demand taken from activation of the fixed suppression systems, plus the maximum hose stream demand of not less than two (2) hydrants for a minimum duration of two (2) hours. The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required (refer to Section 7.1.1.7 for further detail).

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

7.1.1.3.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

7.1.1.4 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

7.1.1.5 Dedicated Piping and Pumping Systems

Piping systems associated with the storage and handling of LPG in its gaseous or liquefied state shall be in accordance with SANS 10087 [44], [45], with guidance also sought from NFPA 54 [68], NFPA 55 [69] and NFPA 58 [70].

This typically calls for the use of steel pipes for conveying liquid, and steel or solid drawn copper for pipes conveying vapour.

As part of the Fire Protection/Detection Assessment process the following measures should also be considered as part of the design:

- Location of any emergency shut off valves.
- Any buried pipes should be at a depth where any future works will not damage, or restrict the flow of gas.
- Measures to identify the location of buried pipes at grade level.
- Measures to restrict corrosion in buried pipelines.
- Any concealed pipes to be sleeved.

7.1.1.6 Shut-off, Control and Sensing Valves

It is preferred that fixed fire protection system be actuated by mechanical means as far as possible.

The control or release device for a pre-action deluge system may be a sprinkler head or suitable detector for the environment. The releasing device should be able to actuate the release of water, effectively charging the system. If a thermal releasing device is selected its operating temperature should be lower than that of the sprinkler head activation temperature. This ensures water is available at the point or area to be protected in the event of a fire. A second sprinkler head is required to activate (at a temperature point higher than the releasing device) before water is discharged over an affected area. This approach is effectively a double knock type approach, requiring a minimum of two detection points to activate prior to water discharging. This approach assists with reducing the likelihood of false alarms and the unnecessary discharge of water.

Alternatively, should protection against false alarms and unnecessary discharge of water not be required the deluge system may be actuated via the operation of a single sprinkler head which detects the fire, with the water discharged via a series of water sprayers located to protect the area or equipment in question.

As required by NFPA 13 [61] the detection devices or systems are to be remotely monitored, which alerts operatives that either the release device or the suppression system has actuated. Remote monitoring of the system should typically be provided within the main Control Room, and also at the Main Fire Alarm Panel.

7.1.1.7 Fire Service Facilities – Fire Hydrant Systems

The provision of fire hydrants adjacent to any gas storage facilities should be considered as part of the Fire Protection/Detection Assessment process (FPDA) in tandem with any fixed protection system installed to provide a fall back fire-fighting strategy for this area. It will allow remote fire-fighting operations to be carried out, allowing cooling and damping down of facilities at a safe distance. Hydrants around an LPG installation shall conform to SANS 10087 [44], [45].

Where fire hydrants are provided, it is recommended, in tandem with the Eskom emergency response procedures, that flat fire hoses and suitable nozzles for the hoses are provided adjacent the gas storage facility fire hydrant system, in a dedicated, signed red box for fire fighter use.

Fire hydrants shall be located as a minimum at intervals of 60 m. Due consideration should also be given to the requirements in Section 5.10.3 pertaining to system design.

7.1.1.8 Fire Resistant Separation Requirements

Fire areas shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities.

Fire separations should typically have no openings other than:

- For closures such as door sets
- Penetrations complying with 7.1.1.9.

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

Fire barriers rated to provide a minimum of 2 hours fire resistance (both integrity an insulation rating) shall, as a minimum, be provided in the following areas:

- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.

Fire barriers shall be spaced at intervals that will prevent the spread of fire to more than one boiler/turbine generator building or to any other adjacent area.

Fire area boundaries shall be determined based on consideration of the details provided within Section 5.3.1 of this standard.

7.1.1.9 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

7.1.1.10 Testing and Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

7.1.2 Fuel Handling and Storage - Hydrogen

7.1.2.1 General

The hydrogen generating plant, receivers, cylinders and all associated plant shall comply with the requirements of the Eskom document, Hydrogen Systems Specification [117], NFPA 2 [58], and NFPA 55 [69].

7.1.2.2 Fixed Protection System

As part of the Fire Protection/Detection Assessment process the requirement for a fixed automatic sprinkler system to be provided to protect the building containing hydrogen generating plant, or specific items of plant, should be considered. If the hazards and associated risks identified require protection to be installed the system should be designed in accordance with Eskom document, Hydrogen Systems Specification [117] and NFPA 13 [61].

Standard practice for fixed fire protection of receivers and cylinders is a deluge water spray system with medium velocity spray nozzles. The system should be designed to provide a minimum water flow rate of 10.2 L/min/m^2 for each square meter of surface area of the storage vessels. In addition all pipes and valves within 2 m of the storage vessel should also be protected.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard

Given the near invisible flame of a hydrogen fire, untrained personnel should not attempt to extinguish any flame. The control of hydrogen to the fire should be disconnected by a trained engineering operative or appropriate automatic shutdown system, with any attempt to extinguish a hydrogen fire carried out by trained fire-fighting staff members.

7.1.2.3 Fire Water Systems

7.1.2.3.1 Water Supplies

The water supply or supplies for fixed fire protection installations shall as a minimum be based on the fire scenario with the largest designed fire water demand taken from activation of the fixed suppression systems, plus the maximum hose stream demand of not less than two (2) hydrants for a minimum duration of two (2) hours. The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required.

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

7.1.2.4 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

7.1.2.5 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

7.1.2.6 Dedicated Piping and Pumping Systems

All piping and pumping systems shall be well supported and protected against mechanical damage. Remote controlled insulation valves shall be provided at the hydrogen storage location to enable each unit to be isolated separately (i.e. not affecting supplies to other units in an emergency).

The routing of hydrogen pipework should avoid any area assessed as hazardous during the course of the Fire Protection/Detection Assessment process, and through any areas containing items of plant or equipment considered to be critical.

All electrical equipment for the hydrogen handling, including seal oil pumps and valves shall be of the type approved for a Zone 2 location, and shall comply with the requirements of SANS 10108 [49] and NFPA 2 [58].

As part of the Fire Protection/Detection Assessment process the following measures should also be considered as part of the design:

- Location of any emergency shut off valves.
- Any buried pipes should be at a depth where any future works will not damage, or restrict the flow of gas.
- Measures to identify the location of buried pipes at grade level.
- Any concealed pipes to be sleeved.
- The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.2.7 Shut-off, Control and Sensing Valves

7.1.2.7.1 General Valve Arrangement

Control room discrepancy alarms shall be provided to indicate gas pressure, temperature and percentage of hydrogen in the vicinity of the generator.

Hydrogen sensing lines shall not be piped into the control room.

The generator hydrogen dump valve and hydrogen detraining equipment shall be arranged to vent directly to a safe outside location with remote operation capability. Carbon dioxide purging shall also be capable of being operated from a remote location.

Procedures and controls shall be established for the operating staff to monitor the usage and make-up of hydrogen within the system. In this manner, the detection of leaks can be monitored.

7.1.2.7.2 Emergency Shut Off Valves

In case of emergency dedicated manual, or automatic operating shut off valves to control the flow off hydrogen should be provided. The valves should be located in an easily accessible position, close to the area or item of equipment to be isolated. In addition a common alpha numeric system for the identification of all items of plant and materials is adopted by Eskom to ensure the correct system and associated isolating valve is operated.

The actual number and final position of the emergency shut off valves shall be determined during the Fire Protection/Detection Assessment process but shall typically be provided at the following locations:

- Bulk source or piping systems serving a bulk supply;
- Located at the tank, cylinder, or source of bulk fuel,
- At any point where a piped systems enters a building.

7.1.2.8 Fire Resistant Separation Requirements

Fire areas shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities.

Fire separations should typically have no openings other than:

- For closures such as door sets.
- Penetrations complying with 7.1.2.9.

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

Typically the storage of hydrogen related fuels should be provided within structures separated from adjacent areas via the distances detailed within Section 4 of this report. Should these separating distances not be achievable the following separation requirements should be provided:

- Gas Storage Rooms - 2 hour fire resistant construction.
- Hydrogen Gas Storage Rooms – 2 hour fire resistant construction.
- Liquefied hydrogen storage – 2 hours fire resistant construction.

7.1.2.9 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

7.1.2.10 Testing and Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

7.1.3 Fuel Handling and Storage – Oil/Fuel

7.1.3.1 General

Fuel oil pumping and/or heating facilities shall be arranged in accordance with paragraph 5.1 of this document.

Fuel oil storage, pumping facilities and associated piping shall comply with SANS 10089 Parts I and III [46], [47], and SANS 10131[50]. The recommendations of NFPA 30 [65] and NFPA 31 [66] shall also be taken into consideration as should the recommendations of FM Data Sheet 7-88 [99] be taken into consideration.

Where fuels require heating, fuel heaters shall be equipped with automatic high-temperature sensors to shut off the heat source should the operating thermostat fail.

7.1.3.2 Fixed Protection System – Indoor Facilities

Automatic fire suppression shall be provided to the following indoor locations:

- Fuel pumping facilities

- Fuel heating facilities
- Areas where bulk storage of fuel oil is contained

There are a number of possible fire suppression systems that may be used within the areas associated with oil storage and oil pumping facilities. These being:

- Automatic Sprinklers
- Automatic Water Deluge System
- Automatic Water Mist
- Foam type suppression
- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (sealed rooms – inert gases)

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of any gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation/air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system.

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

During the Fire Protection/Detection Assessment process the most suitable fire suppression systems for the area and equipment to be protected should be selected. Consideration should be made to the containment provisions (i.e. bunded - contained/non-bunded areas) as a water based system may spread a spill of burning oil or liquid should it not be contained. Further detail on the South African National Standard requirements for bunds and containment can be found within SANS 10089 Parts I and III [46], [47].

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.3.3 Fixed Protection Systems – Outdoor Facilities

During the Fire Protection/Detection Assessment process the provision of suppression to outdoor storage tanks should be considered. A foam suppression type system is considered to be the most appropriate form of protection, with the design taking into consideration the effect of a fire on the tanks themselves, and a fire due to oil spill, its containment, and its effect on surrounding structures.

Additionally automatic drainage may be provided in addition to a fixed suppression system providing protection, linked to a dedicated oil sump located below ground beneath the storage area. This option shall be subject to a Rational Fire Engineered Design approach to assess whether it is a viable option, both from a life safety and business continuity/protection view point.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

Standard practice for fixed fire protection of storage tanks is a deluge water spray system with medium velocity spray nozzles. The system should be designed to provide a minimum water flow rate of 12.2 L/min/m^2 for each square meter of surface area of the storage tanks.

7.1.3.4 Fire Water Systems

7.1.3.4.1 Water Supplies

Consideration should be given to the requirements The water supply or supplies for fixed fire protection installations shall as a minimum be based on the fire scenario with the largest designed fire water demand taken from activation of the fixed suppression systems, plus the maximum hose stream demand of not less than two (2) hydrants for a minimum duration of two (2) hours. The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required (refer to Section 7.1.3.8 for further detail).

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

7.1.3.4.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

7.1.3.5 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

7.1.3.6 Dedicated Storage, Piping and Pumping Systems

Fuel oil storage, pumping facilities and associated piping shall comply with SANS 10089 Parts I and III [46], [47], and SANS 10131[50]. The recommendations of NFPA 30 [65] and NFPA 31 [66] shall also be taken into consideration.

As part of the Fire Protection/Detection Assessment process the following measures should also be considered as part of the design:

- Location of any emergency shut off valves.
- Any buried pipes should be at a depth where any future works will not damage, or restrict the flow of fuel oil.
- Measures to identify the location of buried pipes at grade level.
- Any concealed pipes to be sleeved.

7.1.3.7 Shut-off, Control and Sensing Valves

Fuel tanks outflow piping shall be equipped with emergency shut-off valves to stop the flow of fuel in the event of a fire. The provision of non-return valves in fuel oil distribution pipe work shall be ensured to prevent the back flow of fuel into a fire area.

NFPA 850 [90], in particular Chapter 7 – Identification of and Protection against Hazards should be consulted to ensure all shut off, control, and sensing valves are considered during the design of the Fuel Oil facilities.

7.1.3.8 Fire Service Facilities – Fire Hydrant Water Supply for Outdoor Oil Storage Facilities

The provision of fire hydrants adjacent to any outdoor fuel oil handling or storage areas should be considered as part of the Fire Protection/Detection Assessment process (FPDA) in tandem with any fixed protection system installed to provide a fall back fire-fighting strategy for this area. It will allow remote fire-fighting operations to be carried out, allowing cooling and damping down of facilities at a safe distance.

Where fire hydrants are provided, it is recommended, in tandem with the Eskom emergency response procedures, that flat fire hoses and suitable nozzles for the hoses are provided adjacent the oil storage facility fire hydrant system, in a dedicated, signed red box for fire fighter use.

Fire hydrants shall be located as a minimum at intervals of 60 m. Due consideration should also be given to the requirements in Section 5.10.3 pertaining to system design. . Further details on the site wide reticulation system feeding the hydrant system can be found within Section 5.10.1.

Fire hydrants shall be provided for manual fire protection, and located such that access to them will not be impeded by fire.

7.1.3.9 Fire Resistant Separation Requirements

Fire areas shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities. All indoor fuel oil pumping or heating facilities shall be separated from adjacent areas via a minimum of 2 hours fire resistance.

Fire separations should typically have no openings other than:

- For closures such as door sets
- Penetrations complying with 7.1.3.10.

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

Fire barriers rated to provide a minimum of 2 hours fire resistance (both integrity an insulation rating) shall, as a minimum, be provided in the following areas:

- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.
- Windows in fire barriers are to be provided with a fire shutter or automatic water curtain.
- Fire resistant glazing rated to provide the same integrity and insulation rating as the fire rated wall it is installed within.

Fire barriers shall be spaced at intervals that will prevent the spread of fire to more than one boiler/turbine generator building or to any other adjacent area.

Fire area boundaries shall be determined based on consideration of the details provided within Section 5.3.1 of this standard.

7.1.3.10 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

7.1.3.11 Indoor Pumping Facilities – Flammable Vapour Ventilation

7.1.3.11.1 Ventilation Requirements

The build-up of hazardous flammable vapours associated with fuel oil storage and associated pumping and piping facilities within indoor fuel oil pumping facilities should be restricted. Ventilation can be designed to be mechanically assisted (use of extract fans), or via natural means (louvres, openings in external facades) for systems containing flammable or combustible liquids. Care should be taken when designing any system to ensure adequate high and low level ventilation is provided, to clear any vapour emitted that is denser than air. The system/s should be designed such that they cover all areas where flammable vapour may collect. The exhaust rate from the area should ensure that concentration of flammable vapours is kept below 25% of the lower explosion limit. Ventilation rates are typically a minimum of $0.071m^3/sec$ or $0.3m^3/min/m^2$, whichever is greater.

7.1.3.11.2 Discharge of Flammable Vapour

During the design process the location of the flammable vapour system discharge point should be taken into consideration to ensure the flammable vapours are not discharged into an area where ignition may occur (i.e. adjacent heat sources, ignition sources, areas containing static electricity generation, to a confined space where the vapours may re-build due to inefficient ventilation etc.). Typically the discharge point should be located at high level, above the roof of the structure from the area which it is extracted. The final discharge point should be positioned such that it is remote from any ventilation opening, or fresh air intake point.

The electrical equipment associated with these areas should be confirmed in conjunction with the Electrical Engineering Department.

7.1.3.12 Testing & Maintenance of Systems

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

7.1.4 Bulk Materials Handling and Storage

7.1.4.1 General

Bulk materials handling structures shall be designed for open construction, allowing natural ventilation to prevent accumulation of combustible dust and flammable gas, except as modified for explosion venting. Where enclosed structures are necessary, a means of controlling dust and combustible gases shall be provided.

Due to the nature of materials handling, an ever present danger exists of fire or explosion occurring as a result of dust generation. The control of dust generation and the risk it poses should be considered during the Fire Protection / Detection Assessment process, with appropriate measures incorporated as required.

7.1.4.2 Bins, Bunkers, Silos

Coal piles are typically subject to fires caused by spontaneous heating of the coal. In the first instance coal piles, as well as any other material being stored or dumped, shall typically be provided in external air, with access provided to tackle and control any developing fire situation.

It is not always possible to provide open air storage facilities, and it is recognised that indoor storage facilities may be required. There are a number of items to consider during the design process when storing coal, or other material, indoors, including the most appropriate fire protection system.

7.1.4.2.1 Fixed Protection System

Due to the difficulty of extinguishing a fire in a silo or coal bunker means of removing coal from the area should be considered as part of the fire protection system. This may be in the form of conveyors removing coal to a safe area outside of the storage facility, and located where it cannot damage any other building or structure.

Should it not be possible to remove all the coal a micelle-encapsulating agent should be considered for insertion into the internal storage area. It is critical that the structural stability of the silo or coal bunker be considered before water is discharged into it. If it is considered unsafe to discharge water into the silo or coal bunker then injection of an inert gas should be considered.

The guidance provided within the Fire Detection and Life Safety Design Standard [5] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The distribution pipework network and its associated fixtures and fittings for the suppression system should take into consideration the detail provided within Section 5.10 of this Standard.

A structural engineer should be consulted wherever a water based suppression system is installed within a silo or bunker (whether it contains coal, ash, lime or gypsum) to determine whether the additional weight introduced will impact upon the design of the overall structural support provided.

7.1.4.2.2 Fire Resistance Separation Requirements

Fire areas shall be separated from each other by approved fire barriers or construction to minimize the risk of fire spread and the resultant consequential damage from fire gases, smoke, heat and fire-fighting activities. All indoor fuel oil pumping or heating facilities shall be separated from adjacent areas via a minimum of 2 hours fire resistance.

Fire separations should typically have no openings other than:

- For closures such as door sets
- Penetrations complying with 7.1.3.10.

Fire area boundaries shall be determined based on consideration of the following:

- Types, quantity, density and location of combustible material.
- Location and configuration of plant and equipment.
- Consequences of losing plant and equipment.
- Location of fire detection and suppression systems.
- Personnel safety/exit requirements.

If a fire area is defined as a detached structure, it should be separated from other structures by an appropriate separation distance. Section 4 of this document provides detail on the determination of separation distances to be maintained.

Fire barriers rated to provide a minimum of 2 hours fire resistance (both integrity an insulation rating) shall, as a minimum, be provided in the following areas:

- All openings in fire barriers shall be provided with fire door assemblies, fire dampers or penetration seals with a fire resistance rating equivalent to the designated fire resistance rating of the barrier.
- Windows in fire barriers are to be provided with a fire shutter or automatic water curtain.
- Fire resistant glazing rated to provide the same integrity and insulation rating as the fire rated wall it is installed within.

Fire barriers shall be spaced at intervals that will prevent the spread of fire to more than one boiler/turbine generator building or to any other adjacent area.

Fire area boundaries shall be determined based on consideration of the details provided within Section 5.3.1 of this standard.

7.1.4.2.3 Fire Stopping and Intumescent Coating of Cables

Fire stopping and intumescent coating of cables shall be determined based on consideration of the details provided within Section 5.3.2 of this standard.

7.1.4.3 Bulk Material Conveyors and Handling Structures

7.1.4.3.1 General

Bulk material conveyor belts, their structures and supports shall be constructed from non-combustible materials where possible. Typically Eskom does not make use of fire resistant belts and it cannot be assumed that these belts will be used to limit the down time to the system in the event of a fire.

Where the construction of the bulk material conveyor system cannot be carried out in open air (i.e. open construction) an explosion venting system should be considered during the Fire Protection/Detection Assessment process and incorporated into the design. Any system should take into consideration the recommendations within NFPA 68 [72].

All electrical equipment within the bulk materials handling system areas, which are subject to coal dust, shall be of the type approved for a Zone 22 location, and shall be in accordance with SANS 10108 [49].

Any hydraulic system associated with the bulk materials conveyor system should only use fire retardant fluids. Should fire retardant fluids not be available or used, consideration should be made to protecting the pipework with an appropriate fire suppression system.

Consideration to the installation of draft barriers along the length of any subterranean coal conveying system should be considered during the Fire Protection / Detection Assessment process. They will have the effect of separating the conveyor system into a number of areas, effectively restricting the flow of smoke and in turn reducing the time for the detection or suppression system to actuate.

7.1.4.3.2 Fixed Protection System – Bulk Materials Handling Conveyor Belts

Where bulk materials handling conveyor belts are considered to form a critical system for continuous power generation a water spray (deluge system) or sprinkler system shall provide fire protection to the whole of the system. For sprinkler protection the system should be designed to provide a minimum density of 10.2 mm/min density over 186 m^2 of enclosed area or the most remote linear 30m of conveyor structure up to 186m^2.

Where a sprinkler system is provided to protect the bulk materials conveying system the Fire Protection designer should take into consideration the location of the sprinkler heads above and around the system to ensure they are located directly in the path of any heat generated from a fire on the belts and any associated surfaces.

Should a water spray system be considered more appropriate due to shielding effects that may occur to sprinkler heads given the location of the conveyor belt and its supporting structure (as determined during the Fire Protection/Detection Assessment process) then the system should be designed in accordance with the design criteria listed within NFPA 15 [62].

Where the conveyor system is inclined at a pitch greater than 10 it is possible any fire may 'race ahead' of the suppression system protecting the belt. Careful consideration during the Fire Protection/Detection Assessment process to the type of suppression protecting these belts and the number of points operating should be made to ensure any fire does not spread faster than the system may operate.

For information only the following table highlights the differing rates of flame spread across paper strips laid over an inclined surface:*

Orientation	Rate of flame spread (mm/s)
0°	3.6
+22.5°	6.3
+45°	11.2

+75°	29.2
+90° (vertically upwards)	46-76 (erratic)

*information taken from Table 7.2 – An Introduction to Fire Dynamics 2nd Edition – Dougal Drysdale

Where there is a possibility of electrical components being damaged by water from the fire suppression system, consideration shall be given to protecting these components by proper positioning of water spray nozzles, or by providing water deflection shields. Electrical components to be protected from water damage include:

- Motorized drive equipment
- Belt alignment switches
- Motion sensing devices
- Belt misalignment disconnect switches

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

7.1.4.3.3 Fixed Protection System – Underground Coal Conveyors

Conveyor systems that are below grade or enclosed provide an extremely hazardous environment to maintenance and fire-fighting personnel required to work within these areas. Underground bulk materials handling conveyors, located within the power station boundary fence, shall be provided with hose reels, hydrants and fixed sprinkler systems dependent on the Fire Protection/Detection Assessment process. Any decision to incorporate the above systems to protect the underground bulk materials handling conveyors must be documented as part of the Fire Protection/Detection Assessment process.

The guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.4.3.4 Fixed Protection System – Handling Structures

Where facilities and handling structures are considered critical to power generation, automatic water deluge or sprinkler systems should be provided for protection. Any sprinkler system should be designed to provide a minimum density of 10.2mm/min over an area of 232m^2. The same density of coverage may also be used should a water spray system (deluge system) be installed instead of sprinklers.

Transfer houses and inclined conveyors shall be protected against structural fire damage by means of sprinkler or water spray system. This shall include the head and tail ends of conveyors.

Any system installed should be designed accordance with NFPA 13 [61] or 15 [58].

The guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

Draft barriers installed at the end and midpoints of enclosed conveyors and between separate sprinkler and water spray systems where the length of the conveyor requires multiple systems should be considered in the Fire Protection/Detection Assessment. Draft barriers will improve the response time of installed automatic sprinkler or detection systems and minimize the chimney effects in the event of fire.

The requirement for water spray curtains must be determined by carrying out a Fire Protection/Detection Assessment, taking into account structural layouts, ventilation, drainage, thermal updrafts and windage. Water spray curtains are less effective than direct application but can, under favourable conditions, provide some protection against fire exposure and smoke propagation through subdivision of fire areas.

7.1.4.3.5 Fixed Protection Systems – Enclosed Electrical Control Cabinets for Conveyor Systems

Where bulk materials handling conveying systems are considered critical to the power generation process, consideration should be given to providing in-cabinet suppression to the electrical controls to limit the down time should a fire occur within these areas. An automatic gaseous suppression type system would be most suitable for this application. There are a number of methods suitable for activating the system, each providing a differing level of protection to the electrical control cabinets based upon the time to detection.

Option 1 would be for a fixed temperature detector to be provided. This would require a significant build-up of heat to be generated with the detector activating at a pre-determined set temperature (temperature to be determined during the Fire Protection/Detection Assessment process) with appropriate heat detectors provided.

Option 2 would be for the provision of a rate of rise heat detector which operates upon a rapid rise in element temperature. This would again require a significant fire to occur before the detector would operate.

Option 3 would be the provision of an in cabinet aspirating smoke detection system. The inclusion of an aspirating smoke detection within the cabinet would monitor for signs of smoke production (through slow degradation of insulation or similar) during the incipient stage of a fire, resulting in quicker activation times of the in-cabinet gaseous suppression, safeguarding electrical supplies to potentially critical systems.

The guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

Any gaseous system provided should be designed in accordance with NFPA 2001[90] and SANS 14520 Part 1 [56].

7.1.4.3.6 Coal Stacker-Reclaimer

Consideration should be given to the installation of an Automatic Water Deluge or sprinkler system over the conveyor belt and striker plate areas within the stacker-reclaimer. The water supply could be from a 11,355 L to 18,925 L capacity pressure tank located on-board. A fire department pumper connection should be provided so connection can be made to the fire hydrants in the area during down or repair periods to provide a more adequate water supply. Consideration should be given to protecting enclosed electrical control cabinets by a pre-engineered fixed automatic gaseous-type suppression system actuated by a fixed temperature detection system.

7.1.4.3.7 Ash Stacker

Consideration should be given to the installation of an automatic water deluge or sprinkler system over the conveyor belt and striker plate areas within the stacker. The water supply could be from a 11,355 L to 18,925 L capacity pressure tank located on-board. A fire department pumper connection should be provided so connection can be made to the fire hydrants in the area during down or repair periods to provide a more adequate water supply. Consideration should be given to protecting enclosed electrical control cabinets by a pre-engineered fixed automatic gaseous-type suppression system actuated by a fixed temperature detection system.

7.1.4.4 Fire Water System

7.1.4.4.1 Water supplies

Consideration should be given to the requirements The water supply or supplies for fixed fire protection installations shall as a minimum be based on the fire scenario with the largest designed fire water demand taken from activation of the fixed suppression systems, plus the maximum hose stream demand of not less than two (2) hydrants for a minimum duration of two (2) hours. The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required (refer to Section 7.1.4.7 for further detail).

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

7.1.4.4.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

7.1.4.5 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

7.1.4.6 Shut-off, Control and Sensing Valves

Activation of the fixed protection system (water spray or sprinkler system) should shut down the conveyor belt involved in the fire situation and any belts feeding into the belt under fire conditions.

It is preferred that fixed fire protection systems be actuated by mechanical means as far as practicably possible.

The sprinkler or water spray control valve should be located in an area or enclosure separated from the conveyor system to ensure it cannot be damage by fire on the conveyor system, thereby restricting its operation.

Any fans or dust collection systems shall also shut down to restrict the spread of smoke along the conveyor belt system upon activation of the automatic detection or suppression system protecting the conveyor belts.

7.1.4.7 Fire Service Facilities

7.1.4.7.1 Hydrants

The provision of fire hydrants to any part of the bulk materials conveying or handling system shall be considered as part of the Fire Protection/Detection Assessment process (FPDA), in tandem with any fixed protection system installed to provide a fall back fire-fighting strategy for this area. It will allow remote fire-fighting operations to be carried out, allowing cooling and damping down of facilities at a safe distance. Typically hydrants and their associated water supply pipework shall be installed to protect the following areas where practical:

- Adjacent overland conveyor systems

- To provide protection and coverage to coal, limestone and gypsum stockyards
- Underground conveyor systems

Where fire hydrants are provided, it is recommended, in tandem with the Eskom emergency response procedures, that flat fire hoses and suitable nozzles for the hoses are provided adjacent the area to be protected in a dedicated, signed red box for fire fighter/Eskom Fire Response Team use.

Fire hydrants shall be located at intervals of 60 m (for overland conveyors, 90 m to 150 m spacing is acceptable). Due consideration should also be given to the requirements in Section 5.10.3 pertaining to system design.

Fire hydrants shall be provided for manual fire protection, and located such that access to them will not be impeded by fire.

7.1.4.8 Fire Separation

Refer to Section 4 for detail on the separation requirements to be provided between bulk materials conveying systems and the surrounding areas and buildings.

7.1.4.9 Testing & Maintenance of Systems

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

7.1.5 Steam Generator and Associated Equipment

7.1.5.1 General

Boiler plant protection shall be provided where the hazards associated with oil fired boilers, and the use of oil for ignition of plant poses a risk to operatives working within the vicinity of these areas, and where the generation of power may be affected by a fire situation. The required level of protection should be determined during the Fire Protection/Detection Assessment process. The following sections highlight the fire protection measures to be typically incorporated into specific areas, or to cover items of equipment associated with steam generation plant.

7.1.5.2 Fixed Protection System – Boiler Furnace

Boiler furnaces, or multiple oil fired burners that use oil as an ignition source shall be protected with a fixed protection suppression system. This may be in the form of either of the following systems, which should be designed to cover the fuel oil burners, igniters, and any adjacent fuel oil piping and cable within 20ft (6.1m) from the boiler front. In addition any structural member or walkway within 20ft (6.1m) of the boiler front shall be afforded protection, as should any area where the accumulation of oil may occur:

- Automatic Sprinkler system in accordance with NFPA 13 [61]
- Water Spray Systems in accordance with NFPA 15 [62]
  Sprinkler and Water Spray systems should be designed to provide a minimum density of 10.2mm/min over the area to be protected.
- Foam-water sprinkler systems in accordance with NFPA 16 [63]
- Compressed air foam system in accordance with NFPA 11 [59]

Protection to the boiler furnaces or the boiler burners is to control and stop the spread of a fire on the boiler burners as a result of a fuel oil leak. In the first instance a Fixed Water Spray System is to be provided to protect the burner front from oil spill. Where there is a possibility of electrical components being damaged by water from the fire suppression system (as identified during the Fire Protection/Detection Assessment process), consideration shall be given to protecting these components by proper positioning of water spray nozzles, or by providing water deflection shields. Where this is not possible the FPDA process should be revisited and a more appropriate form of suppression considered or an upgrade of the electrical components be considered to make them less susceptible to water damage.

Isolating valves or controls shall be incorporated into the design to isolate the fuel-oil in the case of a fire situation. The isolation shall be by remote means, typically provided within the Main Control Room under the control of the Unit Operator.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.5.3 Fixed Protection System – Pulverisers

The potential for explosions to occur during the process of pulverizing coal, and the subsequent formation of coal dust, is well known and needs to be controlled at source.

Typically modern pulverisers are provided with in-built explosion suppression systems. These in-built explosion suppression systems also act as fire suppression systems as inert gas (CO_2 or Nitrogen) is introduced into the pulveriser. The operation of the inert gas suppression system should be linked to the control room to indicate to operatives that the detection system installed within the pulveriser that detects a burning fire or an increase in carbon monoxide levels has activated. Typically a detection system alarms once the temperature is in excess of 10% of the normal operating temperature and will actuate the suppression system. In Eskom this activation is done manually. Also the levels of carbon monoxide may be monitored as a means of activating the suppression system however the grade of coal must be confirmed to determine whether a carbon monoxide monitoring system is appropriate.

The introduction of an inert gas to the pulveriser will have the effect of smothering any fire.

Where existing Pulverisers do not have any form of suppression protection installed, the Fire Protection/Detection Assessment process should determine whether its inclusion is required. Ad-hoc gaseous suppression may be introduced, with any design and subsequent installation carried out by a qualified and competent contractor or installer.

Commissioning documents, including handover certificates shall be provided for all passive and active fire protection systems and equipment installed.

Any gaseous system provided should be designed in accordance with NFPA 2001[90] and SANS 14520 Part 1 [56].

7.1.5.4 Fixed Protection System – Feed Pumps

Hydraulic and lubricating oil hazards associated with feed pumps are to be protected by Automatic Water Deluge systems. The spray systems shall be extended to protect areas and equipment below the feed pumps as well as oil channel floor areas. The spray system shall be designed in accordance with NFPA 15 [62].

Where there is a possibility of electrical components being damaged by water (as determined during the Fire Protection/Detection Assessment process) from the fire suppression system, consideration shall be given to protecting these components by proper positioning of water spray nozzles, or by providing water deflection shields, or an upgrade of the electrical components be considered to make them less susceptible to water damage.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.5.5 Fixed Protection Systems – Air Pre Heaters

Air pre-heaters are to be protected by water spray systems. The water spray systems must be capable of providing complete coverage of the rotor heat transfer elements. Open-head water spray nozzles in ducts that oppose the flow of air or flue gas will require nozzle protection. The use of materials for water spray nozzles and piping located in the flue gas stream shall be suitable to withstand the highly abrasive environment.

The system shall be designed for manual operation from a safe location within the air heater area. Additionally the Fire Detection and Life Safety Design Standard [6] should be consulted to determine whether any additional methods for activating the suppression system are required.

Upon activation, the fire alarm system shall sound a local alarm, and also transmit an alarm to the unit and main control rooms.

A drainage system shall be provided to prevent excessive loads, which may be caused by the weight of the water from the actuated spray system on adjacent duct work.

The water spray system should be designed in accordance with NFPA 15 [62].

NFPA 850 [90] recommends that when the rotor or stator is horizontal, water spray applied to the upper surface can be expected to flow by gravity down over plate surfaces. A minimum density of 24.4 mm/min is recommended. Where the rotor or stator is vertical, water spray should be applied to both sides to obtain adequate penetration. A minimum density of 12.2 mm/min is recommended on both sides.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.5.6 Fixed Protection Systems – Scrubber Buildings

7.1.5.7 General

Scrubbers are the main component for flue gas desulfurization. They are used to reduce the overall sulphur emissions from the plant. Typically the supporting equipment associated with a scrubber is enclosed around its base at low level.

7.1.5.8 Fixed Protection System

Typically the materials used to construct a scrubber and its associated buildings should be constructed of non-combustible materials.

Where it is not possible to provide and construct from non-combustible materials a fixed automatic sprinkler system should be installed providing coverage to the full area of the building, providing a discharge flow rate of 8.1mm/min over an area not exceeding 930m^2.

Where non-combustible materials are used standard guidance documents do not call for the inclusion of suppression protection to the scrubber building. During the Fire Protection/Detection Assessment process the necessity to provide, or remove suppression from within a Scrubber Building should be evaluated and determined on a case by case basis, not just solely based upon the construction materials used.

The guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.5.9 Fire Water Systems

7.1.5.9.1 Water Supplies

Consideration should be given to the requirements The water supply or supplies for fixed fire protection installations shall as a minimum be based on the fire scenario with the largest designed fire water demand taken from activation of the fixed suppression systems, plus the maximum hose stream demand of not less than two (2) hydrants for a minimum duration of two (2) hours. The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required (refer to Section 7.1.5.12 for further detail).

The water supply solution shall take into consideration the detail provided within Section 5.10.1 of this Standard.

7.1.5.9.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

7.1.5.10 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

7.1.5.11 Shut-off, Control and Sensing Valves

It is preferred that fixed fire protection systems be actuated by mechanical means as far as reasonably practicable.

Activation of the fixed protection system (water spray or sprinkler system) should shut down the conveyor belt involved in the fire situation and any belts feeding into the belt under fire conditions.

7.1.5.12 Fire Service Facilities – Fire Hydrant Systems

Where fire hydrants are provided, it is recommended, in tandem with the Eskom emergency response procedures, that flat fire hoses and suitable nozzles for the hoses are provided adjacent the area to be protected in a dedicated, signed red box for fire fighter/Eskom Fire Response Team use.

All hydrant connections are to be standardized fittings throughout the station, with replacements readily available in the South African industry.

Fire hydrants shall be located at intervals of 60 m (for overland conveyors, 90 m to 150 m spacing is acceptable). Due consideration should also be given to the requirements in Section 5.10.3 pertaining to system design. . Further details on the site wide reticulation system feeding the hydrant system can be found within Section 5.10.1.

Fire hydrants shall be provided for manual fire protection, and located such that access to them will not be impeded by fire.

7.1.5.13 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [5].

Refer to section 5.12 and 5.13 of this standard for more details.

7.1.6 Turbines and Associated Sub-systems

7.1.6.1 General

The fire protection objective is to minimize, to the greatest practical extent, the frequency and severity of fires and explosions in the turbine-generators and associated subsystems. The evaluation of what measures are 'practical' shall be based on the need for safe, efficient and reliable operation of the turbine-generator and associated subsystems, as well as the cost effectiveness of the fire protection requirements. These measures shall be evaluated during the Fire Protection/Detection Assessment process.

Where the designer requires further information on the protection measures to be provided to the generators and its associated equipment reference should be made to NFPA 850 [90]. All areas that are subject to oil spray fires shall be protected according to the more stringent water density and nozzle spacing requirements of FM Global Data sheet 7-101 [97].

7.1.6.2 Fixed Protection System - Hydraulic Control Systems

Where Hydraulic control systems are provided they should use a listed fire resistant fluid. Where it is not possible to use a listed hydraulic fluid any equipment should be protected by a fixed suppression system. A fixed fire protection system shall be supplied to protect the hydraulic control system including reservoirs and emergency stop, intercept and reheat valves.

The suppression system should either be an automatic sprinkler system or a foam-water suppression system where the system may be affected by spillage of oil. Any system should be designed in accordance with NFPA 13 [61] or NFPA 16 [63].

Any sprinkler system provided shall take into consideration any obstructions caused by equipment, its supporting structure, or associated pipework systems with a design density of 12.2mm/min over a minimum application of 464m^2.

The guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.6.3 Fixed Protection Systems – Lubricating Oil Systems

Any lubricating oil systems should use a listed fire-resistant fluid. Where it is not possible to provide fire resistant fluids a fixed fire suppression system should be considered. The requirement for a fixed suppression system should be determined during the Fire Protection/Detection Assessment process. Any suppression system installed should either be an automatic sprinkler system or a foam-water suppression system where the system may be affected by spillage of oil. Any system should be designed in accordance with NFPA 13 [61] or NFPA 16 [63].

Any cabling provided that is associated with the lube oil pump system shall be protected from exposure to fire. The protection afforded should be rated to provide one (1) hour protection from all adjacent areas. Alternatively separate cable routes for AC and DC cabling may be considered.

Where lubricating oil lines are installed below the turbine operating floor they should be protected with an automatic sprinkler system wherever the accumulation of oil may occur (typically this includes all areas beneath the floor. Actual coverage should be assessed during the Fire Protection/Detection Assessment process. Any system should be designed to an operating density of 12.2mm/min over a maximum area of 464m^2.

Lubricating oil lines located above the turbine operating floor that may be subject to oil accumulation or oil spray or flow shall be protected by an automatic sprinkler system. The sprinkler system should provide protection to **all** areas that may be subject to oil accumulation. The sprinkler system should be designed to operate at a density of 12.2mm/min.

Where lubricating oil reserves and handling equipment are provided they should ideally be separated from the main generator area and installed within a separate room or enclosure.

The guidance provided within the Fire Detection and Life Safety Design Standard [4] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.6.4 Fixed Protection System – Turbine Generator Area

All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray or oil accumulation, should be protected by and automatic sprinkler or foam-water sprinkler system. The most appropriate form of suppression installed should be evaluated as part of the Fire Protection/Detection Assessment process and take into consideration any obstruction caused by equipment, its supporting structure, or associated pipework. Suppression coverage shall include all areas beneath the operating floor in the turbine building. The system shall be designed to have a minimum operating density of 12.2mm/min over a minimum application area of 464m^2. Any system should be designed in accordance with NFPA 13 [61] or NFPA 16 [63].

Should the generator be of the pedestal-mounted type, the designer should refer to NFPA 850 [90], Section 7.7.4.1.4 and 7.7.4.1.5 for additional fire protection measures to be provided, and FM Global Data sheet 7-101 [97] for water density and nozzle spacing details.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.1.6.5 Fixed Protection System – Turbine Generator Bearing

Turbine-generator bearings shall be protected with an automatic closed-head sprinkler system utilizing directional nozzles. Actuation of the sprinkler shall be by automatic means either by the frangible bulb fracturing or upon activation of the automatic detection system. The fire protection designer should refer to the Fire Detection and Life Safety Design Standard [6] for further detail and select the most appropriate form of activating the suppression system as part of the Fire Protection/Detection Assessment process carried out for the project.

The system shall be designed to provide a flow density of 10.2mm/min over all bearings that are to be protected.

An open-head system controlled by Multiple Jet Control (MJC) valves is also considered acceptable for use however the location of the frangible bulb sprinkler head/s which operates the sprinkler system should be carefully considered to ensure they are located directly in the path of heat generated from an issue with the turbine bearing.

7.1.6.6 Oil Pipe Galleries

All oil piping serving the turbine-generator shall be designed and installed to minimize the possibility of an oil fire in the event of severe turbine vibrations. Piping design and installation shall consider the following protective measures:

- Welded construction.
- Guard pipe construction with the pressure feed line located inside the return line or in a separate shield pipe drained to the oil reservoir and sized to handle the flow from all oil pumps operating at the same time.
- Route oil piping clear of or below steam piping or hot metal parts.
- Insulation with impervious lagging on steam piping or hot metal parts under or near oil piping or turbine bearing points.
- Non-combustible coverings (flange guards) around the flange to reduce the possibility of oil spraying onto hot surfaces.

7.1.6.7 Oil Storage Areas

Typically the oil storage area associated with the turbine generator bearing represents the largest concentrated oil storage area in the power plant. An automatic sprinkler or water spray (deluge type) suppression system shall be installed to provide protection to the oil storage areas.

Additionally all oil storage facilities associated with the Turbine Generator Bearing shall be separated from all adjacent areas via one (1) hour fire resistant construction. Should suppression not be provided to the oil storage areas separation rated to three (3) hours fire resistance will be required. Where separation is not provided a suppression system shall be provided as determined as part of the Fire Protection/Detection Assessment process.

7.1.6.8 Fire Water Systems

7.1.6.8.1 Water Supplies

The water supply or supplies for fixed fire protection installations shall as a minimum be based on the fire scenario with the largest designed fire water demand taken from activation of the fixed suppression systems, plus the maximum hose stream demand of not less than two (2) hydrants for a minimum duration of two (2) hours at 20 l/s per hydrant at a minimum pressure of 350 kPa per hydrant, as per Eskom minimum requirements. The actual supply demand should be calculated to take into consideration the actual number of hydrants that may be in operation at any one time, their location in relation to the building or item of equipment to be protected, and the mode of operation required.

Further detail on the site wide reticulation system feeding the hydrant system can be found within Section 5.10.1.

7.1.6.8.2 Pressure and Flow Switches

Pressure switches or flow switches shall take into consideration the detail provided within Section 5.10.7.6 of this standard.

7.1.6.9 Drainage

Consideration should be made to the impact of a fixed suppression system activating and potentially flooding equipment and spreading burning liquids to adjacent areas. Drainage should typically be provided where this is considered to be a problem. Requirements are provided within Section 5.3.4 of this standard.

7.1.6.10 Testing & Maintenance

Testing, Maintenance, & Commissioning of all active and passive systems shall be in accordance with manufacturer's recommendations and the guidance provided within Inspection, Testing and Maintenance of Fire Protection Systems [4] and Inspection, Testing and Maintenance of Fire Detection Systems [4].

Refer to section 5.12 and 5.13 of this standard for more details.

7.1.7 Auxiliary Equipment & Other Structures

7.1.7.1 Cooling Towers

Refer to NFPA 214 [80] and FM Data Sheet 1-6 [96] for details.

7.1.7.2 Auxiliary Boilers

The measures incorporated within Section 7.1.5.2 of this guidance document should be incorporated within any area where auxiliary oil fired boilers are provided. During the Fire Protection/Detection Assessment process the similarities between the two areas identified should be determined to ensure the level of protection afforded to the auxiliary boiler areas is commensurate with the hazard posed and the associated risks with this area are adequately controlled.

7.1.7.3 Bulk Sulphur Tanks

Refer to NFPA 655 [88] for details. Generally manual steam fire protection is provided inside the bulk sulphur tank.

7.2 HYDRO POWER STATIONS

7.2.1 General

As with the coal fired power stations the hydroelectric generating plant should be divided into separate fire compartments to restrict the spread of fire through the plant. The provision of effective fire compartmentation, in tandem with dedicated fire protection systems assists with safeguarding occupants working within the power station, whilst also providing a means for limiting the impact upon property and equipment, and the ability to generate power.

Where identified below, areas should be separated by approved fire barriers, fire resistant construction, or spatial separation as detailed within Section 4 of this Standard.

Generally, unless identified in the sections below, all areas shall be separated from each other via Fire Resistant Construction rated to provide two (2) hours fire separation. Any openings within the fire resistant separation should be protected in accordance with Sections 5.3.1, 5.3.2, 5.7.3, and 5.7.6.

Typically the fire protection system adopted within a coal fired power station is similar to those required in a hydroelectric generating plant. The areas and items of equipment provided (i.e. generators, turbines, transformers etc.) are similar in nature and require the same level of protection as that afforded within its coal fired equivalent. Where the protection to be afforded within a specific area of the hydro-electric power plant is similar, or the same as a coal fired power plant, the reader shall be directed to those sections within this Standard. These sections shall identify the most appropriate Fire Protection measures that may be included within a specific area within the hydro-electric power plant. Where cross referencing of the areas is not possible, specific detail shall be provided as to the level of protection to be afforded.

7.2.2 Unattended Hydro Plants

Unattended hydro-electric plants, or plants that are operated with minimal staffing, require fire protection measures to be provided that are capable of being operated automatically, or remotely, from the area to be protected. User intervention to operate any system cannot be relied upon in these circumstances.

Additionally any emergency response team, or local fire service intervention, may be limited due to the remote location of hydro power plants, and the limited availability of trained staff to tackle any fire.

These factors should be taken into consideration during the Fire Protection/Detection Assessment process (FPDA) to determine whether any additional Fire Protection measures should be incorporated into any design to take into consideration the potential for a delayed response.

Consideration to the method for activating any protection system should be taken into consideration. It may not be possible to manually operate any system therefore the design should take into consideration the likelihood of false alarms occurring due to the method of activation chosen. This review should also take into consideration the effects of unnecessary discharge of water over equipment due to the method chosen for activation of system. Typically water based suppression systems shall be actuated via standard response sprinkler heads operating at a temperature of 68°C. The actual operating method, and most suitable method for the area and/or equipment to be protected, should be assessed during the Fire Protection/Detection Assessment process.

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [5] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

7.2.3 Turbine Generator Hydraulic Control Systems

Where Hydraulic control systems are provided they should use a listed fire resistant fluid. Where it is not possible to use a listed hydraulic fluid any equipment should be protected by a fixed suppression system, with any pipework routed where possible from electrical equipment or other sources of ignition. A fixed fire protection system shall be supplied to protect the hydraulic control system including reservoirs and emergency stop, intercept and reheat valves.

The suppression systems suitable for installation to protect the hydraulic control system would be:

- Automatic sprinkler system designed in accordance with NFPA 13 [61]. Any sprinkler system provided shall take into consideration any obstructions caused by equipment, its supporting structure, or associated pipework systems with a design density of 10.2mm/min covering the entire hazard area.
- Automatic foam-water suppression system designed in accordance NFPA 16 [63]. As per the sprinkler system consideration to obstructions caused by equipment etc. should be considered. The design density should be a minimum of 6.5mm/min covering the entire hazard area.
- Compressed air foam systems in accordance with NFPA 11 [59].

Where a water based suppression system is provided consideration to the drainage requirements as detailed within Section 5.3.4 should be taken into consideration during the Fire Protection/Detection Assessment process.

The guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

Water supplies for any suppression system should be evaluated in accordance with the detail provided within Sections 5.10.

7.2.4 Fixed Protection System – Turbine Generator Area

All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray or oil accumulation, should be protected by and automatic sprinkler or foam-water sprinkler system. The most appropriate form of suppression installed should be evaluated as part of the Fire Protection/Detection Assessment process and take into consideration any obstruction caused by equipment, its supporting structure, or associated pipework. Suppression coverage shall include all areas beneath the operating floor in the turbine building. The system shall be designed to have a minimum operating density of 12.2mm/min over a minimum application area of 464m^2. Any system should be designed in accordance with NFPA 13 [61] or NFPA 16 [63].

Should the generator be of the pedestal-mounted type, the designer should refer to NFPA 851 [91] for additional fire protection measures to be provided, and FM Global Data sheet 7-101 [97] for water density and nozzle spacing details.

The suppression system distribution pipework and its associated fixtures and fittings should take into consideration the detail provided within Section 5.10.7 of this Standard.

7.2.5 Fixed Protection System – Turbine Generator Bearing

Turbine-generator bearings shall be protected with an automatic closed-head sprinkler system utilizing directional nozzles. Actuation of the sprinkler shall be by automatic means either by the frangible bulb fracturing or upon activation of the automatic detection system. The fire protection designer should refer to the Fire Detection and Life Safety Design Standard [5] for further detail and select the most appropriate form of activating the suppression system as part of the Fire Protection/Detection Assessment process carried out for the project.

The system shall be designed to provide a flow density of 10.2mm/min over all bearings that are to be protected.

An open-head system controlled by Multiple Jet Control (MJC) valves is also considered acceptable for use however the location of the frangible bulb sprinkler head/s which operates the sprinkler system should be carefully considered to ensure they are located directly in the path of heat generated from an issue with the turbine bearing.

7.2.6 Underground Oil Insulated Transformers

Where it is required that transformers be installed within an underground cavern, section 6.7.2 of this document is to be referenced.

Apart from the required fire protection measures and remedial action taken to deal with the direct consequences of an oil transformer fire, the following factors should also be considered when specifying the scope of Underground Transformer Fire Protection:

7.2.6.1 HVAC

The HVAC system should be designed such that in the event of a transformer fire, the ventilation extraction system is able to provide:

- Isolated and dedicated air extraction of the transformer area. This will ensure that smoke is extracted to the surface via the shortest possible route and will not allow smoke to contaminate other areas.
- Sufficient air extraction flow rates to accommodate the anticipated worst case smoke volume generation rate.

7.2.6.2 Escape Routes

Due to the high risk posed by the oil-filled transformers it must be ensured that, as far as possible, the station emergency escape routes do not go near or past the transformer installations.

7.2.7 Oil Storage Areas (Dirty & Clean)

Typically the oil storage area associated with the turbine generator bearing represents the largest concentrated oil storage area in the power plant. An automatic sprinkler or water spray (deluge type) suppression system shall be installed to provide protection to the oil storage areas.

Additionally all oil storage facilities associated with the Turbine Generator Bearing shall be separated from all adjacent areas via one (1) hour fire resistant construction. Should suppression not be provided to the oil storage areas separation rated to three (3) hours fire resistance will be required.

7.2.8 Generator Pit & Windings

7.2.8.1 Generator Winding Protection

Typically modern generator windings are moulded in a self-extinguishing material which is further encapsulated in a plastic mould protection. The level of fixed protection to provide to such installations should be determined during the Fire Protection/Detection Assessment process to determine whether any additional protection is required. The FPDA process should take into consideration life safety requirements, property protection, and business continuity where the ability to generate power may be disrupted.

Where modern windings are not provided, and there are no immediate plans for their replacement, consideration should be given to providing protection as follows. A combination of gaseous and water based systems may be provided within the area to be protected:

- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (sealed rooms – inert gases)

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation/air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system. Any systems should be designed in accordance with NFPA 2001 [90] and SANS 14520 Part 1 [56].

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

- Automatic sprinkler system designed in accordance with NFPA 13 [61]. Any sprinkler system provided shall take into consideration any obstructions caused by equipment, its supporting structure, or associated pipework systems. The system should be designed to ensure water is discharged across the windings. This can typically be achieved via the introduction of strategically placed water-spray rings.

Additionally the guidance provided within the Fire Detection and Life Safety Design Standard [6] should be considered when designing the fixed protection system, and the most appropriate method for its activation.

Where gas suppression systems are installed, drains and appropriate dampers shall be provided with adequate seals, or the gas suppression system shall be sized to compensate for the loss of suppression agent through the drains.

7.2.8.2 Generator Pit Protection

Where generator pits contain auxiliary circuits such as the following, Protection Current Transformers; Neutral Transformers; Grounding Resistors, which are associated with generator protection, they should be protected by an automatic suppression system:

The following protection systems may be installed to protect the Generator Pit:

- Clean Agent Fire Extinguishing Systems – i.e. Gaseous Suppression (sealed rooms – inert gases)

  Should a gaseous system be provided within any of the rooms its operation should be carefully controlled to ensure any operative is aware the system is about to discharge, so they can evacuate the room prior to the release of gas. Where a gaseous suppression is provided interlocks must be incorporated to isolate ventilation/air conditioning system prior to the suppression system actuation. Motorized fire dampers should also be provided to close on a first knock of the system. Any systems should be designed in accordance with NFPA 2001 [90] and SANS 14520 Part 1 [56].

  (Where it is decided to install gas suppression systems, a room integrity test shall be performed to ensure the room is sufficiently sealed to hold the gas suppression media for the required holding time for the specific gaseous suppression agent).

- Automatic Water Deluge system designed in accordance with NFPA 15 [62]. Any system provided shall take into consideration any obstructions caused by equipment, its supporting structure, or associated pipework systems.

7.2.8.3 Shut-off, Control and Sensing Valves

Where water-spray rings, or any form of water based suppression is provided to protect turbine windings it should be provided with an interlock system linked to the item of equipment it is protecting. The interlock facility should trip the item of equipment being protected prior to the discharge of water.

Where any item of generating equipment has been sprayed with water, it should be mechanically run, **<u>but</u>** electrically isolated and without excitation (i.e. no power provided to the electromagnets), for a minimum of 24 hours to avoid creating stator ground faults in either type of winding provided.

7.3 WIND TURBINE GENERATING FACILITIES

7.3.1 General

This section identifies the fire and explosion risks that exist at wind turbine generating facilities (often referred to as wind farms) and provides guidance for the protection of these facilities to mitigate the risk.

Most wind farms consist of a series of tower mounted wind turbine generators (WTGs) with electrical outputs connected to an electrical distribution system synchronised to the power utility grid. A WTG is a complex machine composed of a tubular tower (up to 130 m high) with the nacelle, hub and rotor blades situated at the top. The nacelle contains the generator that is connected to the hub and rotor blades via a gearbox. Direct current (DC) produced by the generator is fed via power cables to the transformer which converts it to alternating current (AC), and feeds it to the facility substation from where power is fed via high voltage distribution lines to the grid. Access to the nacelle is usually provided via an internal ladder, although lifts are also found in some designs.

As the design of WTGs can vary (e.g. the transformer may be located with the generator in the nacelle, or at the base of the tower), some recommendations in this guideline may be more appropriate to some designs than others. It is however expected that most recommendations will apply. It is up to the users of this document to evaluate the WTG-specific hazards and associated risks, and to apply the recommendations as appropriate to mitigate the risks to an acceptable level within a cost-benefit framework.

Given that these installations are often located remotely and are operated without on-site personnel, the emphasis of fire safety is on the prevention of fire through design. Additional fire suppression measures may be required depending the outcome of the Fire Protection/Detection Assessment process.

The preparation of an Emergency Response Plan (ERP) is also paramount.

7.3.2 Risks

Wind turbines differ from traditional power generation systems in that fire in the nacelle often leads to total loss of the WTG. The reasons for this higher risk exposure are:

- A high proportion of high cost items are located in the nacelle
- High risk of lightning strike and ignition sources in the nacelle
- High concentration of combustibles in the nacelle
- Unmanned operation
- Accessibility issues associated with manual fire intervention
- Remoteness of site

Insurers' loss experience show that apart from the property damage, a significant portion of claims related to high follow-up costs associated with clean-up operations and business interruption.

7.3.2.2 Damage to Property

Fires may occur in a wind turbine nacelle, tower or one of the support structures like the WTG pad-mounted transformer or electrical substation.

The nacelle is especially prone to fire due to the high concentration of electrical ignition sources. Switchgear, control cabinets and often the transformer is located here. Moreover, the confined space is conducive to rapid fire spread and could lead to structural damage to the upper tower segment. As a result, the tower is often lost in totality. Restoration costs often approach the initial installation cost.

7.3.2.3 Service Interruption

Loss experience shows that where wind turbines are damaged it usually takes a considerable amount of time – up to 12 months in the case of total damage to the nacelle – before the turbine can be put back into operation. Components like the turbine, gearboxes and transformers have long lead times, sites are often not readily accessible and the transportation of large components along public routes are contributing factors.

In case of the total loss of a WTG, regulatory and approval processes could cause further delays.

A wind farm's central electrical substation is particularly risk sensitive as it represents a single point of failure where, if damaged by fire, it could result in all connected wind turbines to be disconnected from the power grid at the same time.

7.3.2.4 Bushfire

The falling debris from a fire in a WTG has a high potential to lead to bushfires if the surrounding area is not adequately cleared from vegetation.

This is exacerbated by often long distances between installations and the nearest fire brigade and the strong prevailing winds that usually are encountered at these locations.

In the cases where bushfires ensued, the loss not only concerns the direct property loss of the wind farm, but also the costs associated fire-fighting and damage and consequential loss caused by the bushfire.

7.3.3 Causes of Fire

Causes of fire in onshore and offshore installations are comparable, but the risk is probably higher in offshore installations owing to the corrosive atmosphere and the higher probability of failure of components and equipment.

7.3.3.1 Lightning

Damage resulting from lightning strikes is among the most frequent causes of fire given the exposed location (often located at higher altitudes) of WTGs and the elevated hub heights.

The risk of fire increases particularly when a lightning protection system is either absent or badly designed, installed or not properly maintained.

7.3.3.2 Electrical Installations

Along with lightning, overheating of electrical components as a result of overloading, earth fault/short circuiting and arc welds are among the highest causes of fire. Typical failures include:

- Defective or failure of power electronics
- Failure of power switches
- Defective or failure of control electronics
- High contact resistance owing to loose electrical connections
- Insufficient electrical protection with respect of insulation defects
- No all-pole disconnection of the generator in case of failure/switch-off of the turbine
- Inadequate surge protection at the low voltage side of the transformer
- Resonance within RC circuits (line filter, reactive power compensation)

7.3.3.3 Mechanical Failure

The application of emergency mechanical brakes to slow down the rotor in the event of the aerodynamic brakes having failed could result in the brakes reaching high enough temperatures to cause ignition of combustibles. Furthermore, where brakes are installed without adequate covers, sparks generated may cause ignition of combustible materials located further away. Leaks from lubricating and hydraulic oils could further increase the risk.

Poor lubrication and the overloading of bearings could similarly result in hot surfaces. Failure of generator and gearbox mountings could lead to frictional rubbing, hot surfaces and sparks being generated.

7.3.3.4 Hot Work

Inadequate controls to limit combustibles in the proximity of hot works (welding, grinding, torch-cutting etc.) during maintenance could similarly result in fire. Many fires break out hours after the completion of work involving hazards.

7.3.3.5 Poor Maintenance

Due to the cramped confines in wind turbines and the difficulty in accessing components, the quality of maintenance activities often suffer as a result, thereby increasing the probability of equipment malfunction.

7.3.4 Plant and Equipment Layout

Adequate separation should be provided between the following as determined by the FPDA:

- Adjacent WTGs, taking into consideration the geographical topography.
- Adjacent structures (transformers, substation etc.)
- Adjoining properties and exposures.
- Closest residential buildings.

Owing to risk associated with flying debris, the prevailing wind direction and speed and direction of rotation of WTGs should be considered when establishing separation distances.

7.3.5 Prevention of Fires

Following the NFPA Fire Safety Concepts Tree [86], fires can be prevented by:

- minimising the number and strength of ignition sources
- removal of the fuel from ignition sources
- control of the fuel by selecting non-combustible materials or materials with limited flame spread and ignition properties and low heat release rates

7.3.5.1 Lightning and Surge Protection

WTGs have to be equipped with comprehensive lightning and surge protection systems, specifically designed and tailored for each type of turbine. All possible lightning paths, e.g. from the rotor blade to the hub, nacelle and tower to foundation, kind of electrical installations and equipment including cables etc., should be considered in the design process.

Attention should be given to the allocation of appropriate protection level zones (LPZ) to the various components depending on lightning currents and switching surges that may be expected.

An illustrative example of lightning fire protection zones (LPZ) for a wind turbine (with a metal nacelle) installation is shown in Figure 119 below.

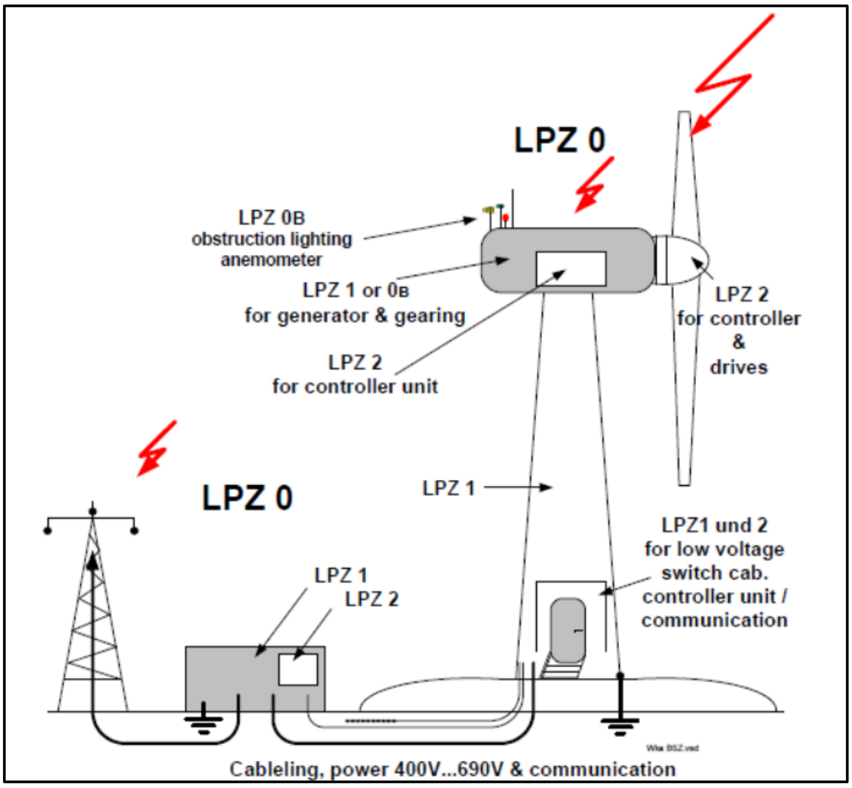


Figure 11: Allocation of lightning protection zones (LPZ) for a wind turbine (with metal nacelle) installation.

The design of the lightning protection system should be in accordance with the IEC 61400-24.

7.3.5.2 Protection of Electrical Systems

State-of-the-art electrical protection technology should be employed to identify electrical faults in components or systems as soon as they arise, and to switch off the affected systems e.g. generator, power line, transformer etc. immediately. The protection systems should ensure immediate switch off of the wind turbine and all-pole disconnection from the power system.

The activation of a protection system should send an alarm signal or notification to the remote control station.

Batteries are frequently used to provide back-up power to control systems in the nacelle and support structures. Care should be taken that batteries are well ventilated and kept clean.

Transformers could be located in the nacelle, tower or at the base of the tower. The plant design should consider the risks associated with transformers.

The design and protection of electrical equipment should be considered taking cognisance of the guidelines in Section 6.

7.3.5.3 Hot Work

Work involving fire hazards relating to maintenance activities should be avoided as far as possible by using cold methods where available. Hot work should only be performed where unavoidable, and then care should be taken that adequate controls have been put into place to ensure that a fire does not start as a result of these activities. Fire precautions should be taken to prevent a fire start prior, during and after maintenance. Measures should also be put into place to detect and fight a possible fire. As such, the work should be constantly supervised by an attending fire watch, equipped with the appropriate fire extinguishers.

Hot work should only be allowed where a hot work permit is issued.

7.3.5.4 Equipment Monitoring and Maintenance

Loss history indicated that many fires result indirectly from equipment malfunction. Methods to limit the frequency and impact of malfunctions are:

- Condition monitoring
- Preventative maintenance
- Facilitating the quality of maintenance

Nowadays, many WTGs incorporate systems that automatically monitor important operating parameters such as temperature and pressure of mechanical and electrical systems like the transformer, generator windings, gearboxes, hydraulic systems and bearings. The condition monitoring systems (CMS) are arranged to signal an alarm condition and to automatically switch off the turbine if limiting values are exceeded. For WTGs, the following monitors and/or trip functions should be provided to monitor the operation of WTGs and to initiate a safe shutdown should abnormal operating conditions occur:

- Grid disturbance
- Yaw errors or limits
- Braking issues
- Abnormal vibration
- Overspeed
- Temperature faults
- Oil condition (lubricating and hydraulic)
- Motor protection
- Communication system errors
- Blade angles
- Battery status

An effective preventative maintenance program should be established and followed in accordance with manufacturer's recommendations. Regular inspections should be carried out, and faulty components and equipment should be repaired or replaced without delay. Controls should be put into place to ensure that remedial actions are taken without delay. Inspections, testing and maintenance activities and rectification works should be documented and regularly reviewed.

Electrical installations and monitoring systems should be examined by suitably qualified personnel on a regular basis preferably not exceeding 2 years.

Transformer insulating oil and gas (where applicable) should be analysed at least every 5 years. Conclusions can be drawn from the condition of the insulating oil in respect of possible electrical defects, thermal overloads of the transformer and the condition of paper dielectric. In respect of dry-type transformers, the surfaces need to be examined annually. Consideration should be given for fitting transformers out with optical detection systems arranged to detect partial discharge.

Thermographic inspections, conducted by suitably qualified personnel, of the following electrical and mechanical equipment should be performed on a regular basis:

- Connection areas and, if possible, the contacts of the LV HRC fuse switch disconnectors
- Clamping devices and connection strips in distribution boards, terminal blocks etc.
- Connection areas and contacts of busbars, contactors, capacitors etc.
- Surface temperatures of transformers, converters, bearings, gearboxes etc.
- Power cables and cable bundles

Lightning protection systems should be inspected by suitably qualified personnel at regular intervals, preferably annually. Inspections should include visual inspection of operability and condition of all air terminals and down conductors, as well as measuring the contact resistance of the conduction path from the air terminals in the rotor blades to the ground terminal lugs and measuring the ground resistance of the foundation.

7.3.5.5 No Smoking

The entire area of the WTG should be declared a non-smoking area. Signs and controls should be put into place to monitor and enforce the policy.

7.3.5.6 Training

Service personnel (internal or external) should be instructed on the fire risks associated with WTGs. Training should include prevention of fire risks, functionality of the equipment including fire protection systems, what to do in case of fire, and how to handle and use fire extinguishers.

7.3.5.7 Separation of Ignition Sources and Combustibles

Possible ignition sources should be located as far as practicable from combustibles. Care should be taken in the routing of electrical cable, location of distribution boards etc.

The principles in NFPA 30 [65] should be applied to gearboxes and lubricating and hydraulic oil sumps, coolers, filters and associated piping containing flammable or combustible fluids. To minimise flammable or combustible fluid piping failures, the piping design should follow the following principles:

- If rigid piping is used, the piping should be designed to accommodate vibrations with freedom to deflect where connecting to fixed components like gearboxes and the likes. The natural frequency of piping systems should be considered in relation to the rotational speed of the gearbox, generator etc.
- Welded piping is preferred above threaded joints.
- Instrument tubing, piping and gauges should be protected against mechanical damage
- Tube-in-tube piping design where the pressure pipe is located within the return pipe should be used for flammable or combustible fluid piping, or alternatively pressure piping should be located within a sleeve to reduce the possibility of oil atomization from pinhole leaks.
- Containment and drainage should be provided for flammable or combustible liquid systems.
- Piping should be routed below electrical reticulation routes and equipment.

Mechanical brakes should be fitted with suitable non-combustible covers to prevent sparks from reaching combustible materials.

Combustible waste (rags etc.) resulting from maintenance activities should be removed immediately.

7.3.5.8 Minimise Combustible Materials

A wide range of combustible materials are to be found in the nacelles of wind turbines and include:

- Foam insulation materials used for noise control
- Plastic housing of the nacelle (e.g. GRP)
- Pinhole leaks in hydraulic systems could result atomised oils sprays with the potential to lead to explosion
- Gearbox oil and other lubricants

- Transformer oil
- Combustible insulation materials used in electrical cables and components

Preference should be given to the selection of listed fire-resistive hydraulic and lubricating oils (preferably non-combustible), or where not possible at least have with a flash point significantly above the operating temperatures of the systems.

The use of foam insulation and plastic materials (GRP) for coverings should be avoided. Combustible materials should be avoided as far as possible, and if unavoidable should be selected on the basis of low flammability. Materials should have impermeable surfaces to prevent the ingress and retention of combustible impurities like oil or dust.

Cable insulation materials should be selected on the basis of not supporting flame spread, have limited smoke production properties and should not give off significant corrosive decomposition products when heated.

7.3.6 Active Fire Protection

Determination of the need for automatic fire detection and/or extinguishing systems should be based on the facility design and outcome of the Fire Protection/Detection Assessment.

7.3.6.1 Fire Detection

Should fire detection be required, these system(s) should be arranged to provide an alarm at a constantly attended location, typically the remote control station. Appropriate detection technologies should be selected following the recommendations in the Eskom Fire Detection and Life Safety Design Standard [6].

7.3.6.2 Automatic Fire Protection Systems

Automatic fire extinguishing systems for WTGs should be considered for the protection of specific equipment, complete rooms or a combination of both.

Extinguishing agents should be selected that leave no residue, are non-conductive and do not have decomposition products that are corrosive. Suitable extinguishing agents include inert gases, other gaseous agents (e.g. Novec 1230), and aerosols. Hydrocarbon gaseous agents having the potential to give off corrosive decomposition products are not recommended for areas containing sensitive electrical equipment.

Sprinkler, water spray and foam-water systems could be used in principle for protecting specific equipment.

The suitability of automatic fire extinguishing systems should be reviewed in conjunction with the manufacturer for each individual turbine, taking cognisance of:

- The operating conditions (temperature, dust, salt containing air for offshore installations etc.)
- vibrations
- ventilation requirements for electrical cabinets, the nacelle, battery enclosures etc.
- environmental impact (firewater runoff, global warming potential and ozone deletion potential etc.)
- effectiveness of extinguishing agent
    - required concentration of gaseous systems
    - residence time for gaseous systems taking cognisance of re-ignition
    - air-tightness of the room
    - pressure-relief
    - volume of the room
    - interfacing with other systems (shutdown of ventilation systems, electrical equipment etc.)

- Installation space requirements (quantity of extinguishing agent, number of cylinders for gaseous agents, location of nozzles etc.)
- Maintenance requirements
- Availability of extinguishing agents and replacement considerations
- Means of automatic activation (type of automatic detection)
- Hazard to personnel when releases accidentally and the need to isolate the system for maintenance
- Reliability
- Consequences of discharge
- Cost

The following table provides an overview of systems that in principle could be suitable for protecting equipment and areas in WTGs:

Table 11: Candidate Fire Protection Systems for Wind Generating Facilities

Room/Installation	Candidate automatic fire protection systems						
	CO_2	Inert gases	Novec 1230	Sprinkler	Water mist (high pressure)	Water spray	Foam
Room protection							
Nacelle with generator, transformer, hydraulic systems, gearbox, brake, azimuth drive	✓	✓	✓	✓	✓	✓	
Hub with pitch drive and generator (if applicable)	✓	✓	✓	✓	✓	✓	
Raised floors with oil sump, cable and electrical installations	✓			✓	✓	✓	✓
Central electrical power substation, switchgear rooms (without transformers)	✓	✓	✓		✓		
Tower base/platform installations (if applicable)	✓	✓	✓	✓	✓	✓	
Installation protection							
Control, inverter, switchgear cabinets (LV/MV), cabinets closed	✓	✓	✓		✓		
Control, inverter, switchgear cabinets (LV/MV), cabinets open	✓				✓		
Transformer	✓				✓	✓	
Hydraulic systems open	✓			✓	✓	✓	✓

Note that the candidate systems listed in Table 11 are systems that potentially could be used; however, the suitability needs to be determined for each individual case. For example, in many instances water-based fire protection systems would be unsuitable given the remoteness of the site, the lack of abundant water supplies, the consequences of accidental discharge, maintainability, fire water run-off issues, shutting down of the system etc.

7.3.6.3 Fault Monitoring

Fire detection and protection systems need to be constantly monitored to ensure its operational reliability especially in light of the remote location of the installations, and the operation of the plant without permanent on-site personnel. Automatic notification of equipment malfunction and system defects (leakage etc.) should be given to provide early indication of potential system faults.

7.3.6.4 Impairment of Safety Installation

Deactivation of safety installations during maintenance should be kept as short as possible, and systems should not be left unattended. A fire mitigation plan should be prepared detailing the temporary measures that should be put into place to detect, fight and extinguish a fire while the system is impaired.

Insurance requirements should be checked to determine whether there is an obligation to inform the Insurer of system impairments.

7.3.7 Emergency Response

An emergency response plan (ERP) should be prepared to limit the loss following fire. The ERP should include at least:

- Identification of the personnel that is on standby to attend an incident
- A written procedure detailing the immediate actions that need to be followed, including:
  - The provision of emergency telephone numbers
  - Notification of the fire brigade and police
  - On-site support for the fire brigade and police
  - Shutdown of the wind turbine and disconnection from the electrical distribution system and power grid if necessary
  - Informing the Insurer
- Standard Operating Procedures (SOPs) in case of fire

The success of the response to fire is highly dependent on a close relationship between the wind farm operator and the attending emergency services. As such, it must be ensured that:

- Frequent planning meetings are held between wind farm personnel and the emergency response services
- Frequent visits are schedule for the emergency responders to familiarise themselves with access routes, the layout and risks associated with the plant, as well as the location and capabilities of fire protection systems
- Emergency response exercises are scheduled and held regularly
- The emergency responders are familiar with the ERP and SOPs are developed collaboratively

7.4 SOLAR POWER FACILITIES - CSP

This section identifies the fire and explosion risks that exist at solar power generating facilities and provides guidance for the protection of these facilities to mitigate the risk.

Solar power converts sunlight into electricity using either photovoltaic (PV) or concentrated solar power (CSP)/solar thermal power. While solar energy is an environmentally safe form of energy generation, it still poses fire risks. It is necessary to be aware of the risks and proper fire protection solutions. The majority of large scale solar power plants are concentrated solar power plants (CSP), which use solar energy to power conventional steam turbines. Therefore, CSP plants have the same fire hazards as many conventional power plants.

CSP plants use a series of lenses, mirrors, or heliostats and tracking systems to condense sunlight into a narrow beam of light. Solar plants have numerous options for technology that condenses the sunlight into a beam: Concentrating Linear Fresnel Reflector, Stirling Dish, Linear Parabolic Reflector/Parabolic Troughs, Solar Dish, or Solar Power Tunnel. The intense beam of light created is then used to provide heat to power a conventional steam turbine. The concentrated beam of sunlight is used as a heat source to warm the heat transfer fluid, molten salt, or steam generator to power the steam turbine. The steam turbine is connected to a generator, which produces the energy.

Because concentrated solar power plants are a combination of solar energy and steam energy, the same fire hazards are present as in many other power plants.

As the design of solar power facilities can vary (e.g. depending on the type of solar technology is utilised), some recommendations in this guideline may be more appropriate to some designs than others. It is however expected that most recommendations will apply. It is up to the users of this document to evaluate the-specific hazards and associated risks with solar power plants and to apply the recommendations as appropriate to mitigate the risks to an acceptable level within a cost-benefit framework.

7.4.1 Risks

Concentrated solar power (CSP)/solar thermal power plants share several of the fire hazards that many standard plants possess as shown in Figure 12. Lube oil systems, transformers, turbine bearings, switchgears, and other areas of concern associated with conventional plants should be considered.

In general, the major hazards associated with solar generating plants are as follows:

- Release of large quantities of combustible heat transfer fluid (HTF)
- Shielded fires involving large quantities of HTF in the heater
- Lubricating and control oil fires
- Switchgear and cable fires

Determination should be made with regard to damage that would be caused by a release of HTF. Spacing and design of critical equipment and structures should be such so as to limit damage in the event of a fire exposure in both the solar field and power generation areas.

In a HTF type plant, the solar field has its own fire hazards. The concentrated sunlight created from the solar field is used to bring the HTF to a high temperature. The HTF flows from the solar field to a standard steam turbine. The HTF is generally a form of oil and can be very combustible. The HTF introduces a fire hazard to the solar field. The HTF pump and pipe racks can be protected with deluge systems and linear heat detection.

The HTF flows until it reaches the heat exchanger which can be another potential problem area. The steam turbine uses lube oil to keep it moving smoothly. Fires can ignite within the turbine underfloor, exciter, lube oil piping, or the turbine bearings. It is recommended that a robust fire protection system is installed in this area. An automatic sprinkler, foam-water sprinkler, or water-spray deluge system is appropriate for the turbine area. An early warning aspirating detection system will ensure that the plant personnel are given adequate notice of a fire ignition. Based on the plant's particular hazards, users of this document must evaluate the-specific hazards and associated risks within the subject plant and apply custom fire protection solution and recommendations as appropriate.

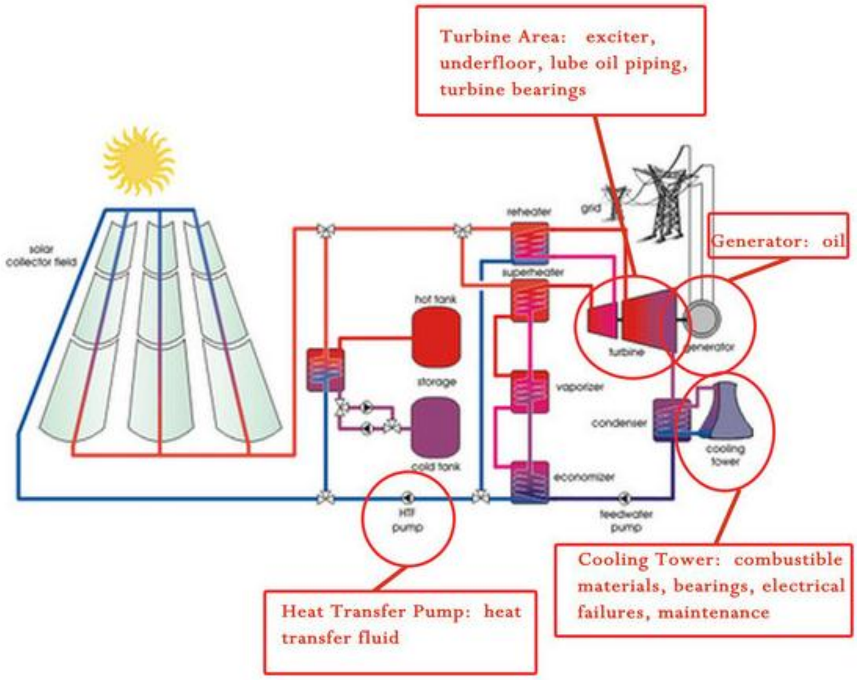


Figure 12: CSP Plant potential HTF fire hazards

The next stage in solar energy generation is the generator, which produces the energy. The generator contains lube oil, and/or hydrogen which can fuel a fire from the slightest spark. To protect a generator, a pre-action sprinkler system or inert gaseous system is ideal. They reduce the likelihood of an accidental discharge while protecting delicate equipment.

Cooling towers are often thought of as fire resistant because they are usually wet; however, cooling towers contain hidden dry areas and are completely dry during maintenance. Cooling tower materials often include combustible materials. The heat source in a cooling tower fire can come from outside sources, such as a fire from another part of the plant that has spread or internal sources, such as maintenance welding, overheated bearings, or electrical failures. A concern within cooling towers is the accelerated corrosion of piping, including fire protection pipes. Plants must take this into consideration and adjust the inspection, testing, and maintenance schedule for this part of the plant.

7.4.2 Heat Transfer Fluid (HTF) – Pumps and Piping

Piping and fittings should be properly designed to resist an exposure fire until protection can be achieved by water spray. To reduce possible sources of leaks, use of rotating ball joint type connections instead of flexible hose connections in areas such as the HTF loop connection of adjacent solar collector assemblies should be considered. Gaskets and seals should be compatible with HTF Flanges and piping connections on HTF systems should have guards.

- Piping and components containing and using HTF should be located outside.
- Pressure monitoring with alarm to a constantly attended area upstream of the HTF heat exchanger and on each HTF loop, and interlocks to shut down pumps or isolate a loop in the event of pressure drop, should be provided.
- Consideration should be given to the use of remotely operated emergency isolation valve(s) in the piping arrangement to reduce the volume of flammable fluid released. Actuators for remotely operated emergency isolation valves should be controlled pneumatically, electrically, or both. Failsafe operation is required (fail in closed position), or cabling should be fire-rated to provide circuit

integrity for a 30 minute exposure to the hydrocarbon fire curve (UL 1709). Remote actuation controls should be located in a fire-resistant room or at least 15.2 m from anticipated leak points.

- Means for draining possible leafing HTF away from important structures should be provided.
- HTF piping and component relief valves should discharge at a location that will limit fire exposure to critical equipment.
- HTF piping should be insulated or routed away from combustible materials.
- The use of double mechanical seals on pumps to reduce potential sources of leaks should be considered.

7.4.3 HTF Heater Protection

- An emergency dump system should be employed to route HTF to a safe location.
- Means should be provided to identify tube rupture, and valving should be provided to isolate the tube where gravity could cause large quantities of HTF to drain from the system.
- The fuel supply to the heater should be capable of being remotely shut off or isolated through action taken in the control room or in a constantly attended area.
- Controls and instrumentation safeguards should be provided for heaters as identified in NFPA [78], and the equipment manufacturer's recommendations. Consideration should be given to include monitoring, alarms, and/or automatic shutdown for the following conditions:
    i. Low HTF flow
    ii. High HTF outlet temperature
    iii. Low fuel gas pressure or low liquid fuel flow
    iv. Flame failure
    v. High exhaust stack temperature

7.4.4 Fire Protection

Supports for steam generator heat exchangers, HTF heaters, and other equipment containing liquid hydrocarbon holdup should be protected to prevent structural collapse of these units in event of a pool fire. In addition, protection for supports for adjacent critical equipment, such as pipe supports, within 6.1 m to 12.2 m, depending on the Fire Protection Design Basis, should be considered. Protect structural supports with either of the following:

i. A 2-hour fire resistance rating when tested by the UL 1709 time-temperature exposure. If a coating is used for outdoor applications, it should be acceptable for outdoor use.

ii. Water spray protection in accordance with NFPA 15 [62].

Equipment such as HTF pumps, surge tank areas, steam generator heat exchanger areas, HTF ullage equipment, and ground area where HTF fluid could spray, flow, or accumulate should be protected by automatic water-based or foam fire protection systems.

An internal fixed fire extinguishing system should be provided for the heater.

Multiple oil-fired burners in the heater should be protected with automatic sprinkler, water-spray, foam, foam-water or compressed air foam systems covering the burner front oil hazard.

Hydrants should be placed strategically about the solar field so as to provide coverage of all HTF piping associated with solar collection assemblies and HTF supply and distribution piping. This will help in early manual fire-fighting and exposure control.

An automatic listed fire protection system should be provided for the following areas based on the Fire Protection Design Basis (where the hazard is lube oil or hydraulic oil, a listed fire-resistant fluid is an acceptable alternative to fixed fire protection):

- Lubrication systems
- Hydraulic control systems
- Electrical equipment rooms, including control, computer, communications, cable trays, and tunnels, in accordance with Section 6.

7.5 PHOTOVOLTAIC (PV) SOLAR POWERED PANEL INSTALLATIONS

7.5.1 General

The purpose of this section is to understand the fire hazards associated with photovoltaic systems. Adding photovoltaic panels to roofs (or walls) of commercial and industrial buildings is a relatively new approach and some of these buildings were involved in fires, which received extensive media coverage. Although many catastrophic warnings did not prove correct, the awareness has risen and the industry is actively working on technologies to prevent and mitigate fire hazards. Thus, the emphasis of this section is on understanding the risks when there are no standard solutions available and to provide guidance for the protection of these facilities to mitigate the risk.

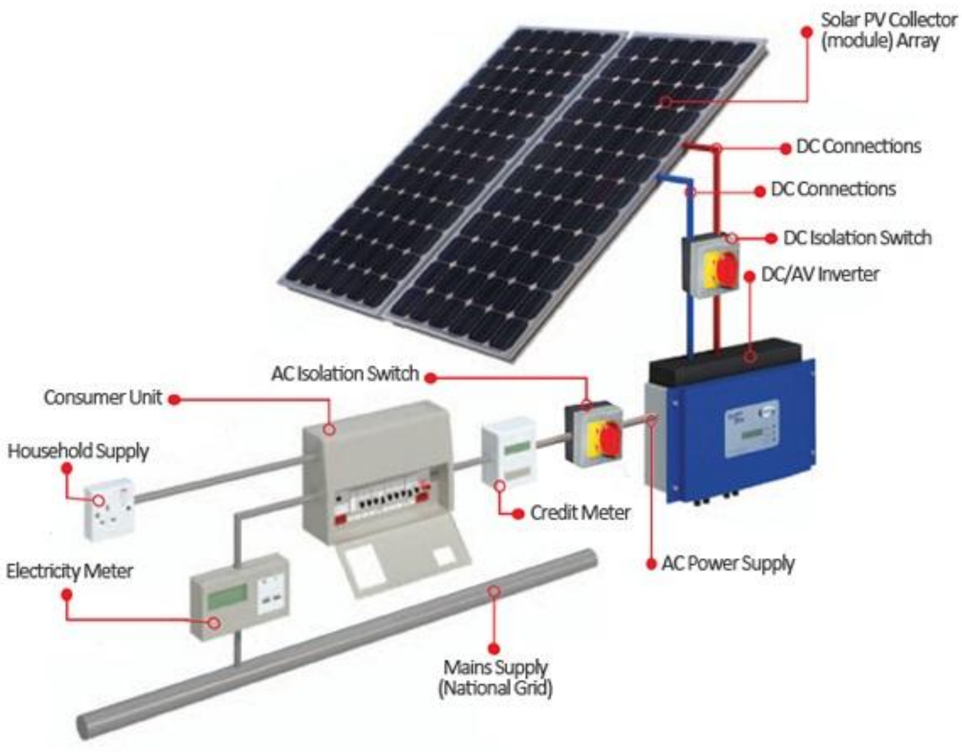


Figure 13: Typical layout of a photovoltaic solar powered panel installation.

7.5.2 Risks

Photovoltaic panel installations have a unique risk to life safety in that when fire fighters arrive at a burning building, one of their first tasks is to disconnect utilities to the structure. However, this is not possible with solar systems since the PV system inverter can hold a charge and send electricity back up to the solar panels. The panels themselves will continue to produce power as long as the sun is shining and possibly even at night when bright lights are present.

Thus, the conduit leading from the PV panels to an inverter remains live with direct current even after the main service panel has been shut-off. The fire services have to fight a fire in the presence of high DC voltage and current and can be subject to electric shock. During the course of fire on a building with a photovoltaic system, DC cable insulation might melt and cause a DC flash arc. The same can happen if a photovoltaic system is disconnected incorrectly. DC arcs are not only an ignition source themselves, but an additional life safety threat to fire fighters

Other possible risks of photovoltaic systems for manual firefighting are:

- Solar panels may block key points and pathways that fire fighters would otherwise use on a roof
- The added weight of a solar panel array may lead to roof collapse, if the integrity of the structure is already compromised by fire
- Potentially toxic fumes from decomposed products of the panels
- Falling objects from the roof top or wall (e.g., broken glass)

7.5.3 Combustibility

All components of a photovoltaic system exposed to sunshine and other exterior elements of weather need to have highly durable characteristics, and certain materials that have traditionally performed well in this regard (i.e., certain types of plastics), do not necessarily have good fire-resistant characteristics. The solar panels themselves typically contain limited plastics, but it is the frames, mounting systems, cables and boxes that can add to the combustible loading of an installation and eventually to the combustibility of the entire roof.

Standards for testing the performance of solar panels have been developed at an international level. While some address electrical performance, others address safety of the modules with respect to construction and operation. These safety standards also address fire behaviour. The safety standards applied are IEC 61730 in Europe / Asia and ANSI/UL 1703 in North America. Both standards are very similar and contain elements of fire testing based on ASTM E-108/UL 790, “Test for Fire Performance of Roofing Materials.”

Factory Mutual plans to test entire PV systems (solar panels and mounting system) in accordance with ASTM E-108 and has already released Approval Standard 4476 for flexible photovoltaic modules and Approval Standard 4478 for rigid photovoltaic modules. In Europe, fire tests for evaluating the behaviour of roof assemblies from external building fires are to be described in ENV 1187 (pre-norm) and classification of the products is described in EN 13501-5. ENV 1187 is not yet a harmonized norm and national standards are still used, such as DIN 4102- 7. These tests are mandatory in Europe for building integrated PV systems.

As a result, the combustibility of a planned photovoltaic installation needs to be evaluated case by case. Fire test results for the panels alone are not enough as an increasing number of mounting systems made from plastics are on the market. There are no harmonized standards for solar cables (cables used in solar installations); however, fire test results and flame retardant characteristics of the cables need to be considered too.

7.5.4 Causes of Fire

Photovoltaic systems are subject to electrical faults like any other electrical installation such as arc faults, short circuits, ground faults and reverse currents. These faults and other failures of the system, including cable insulation breakdowns, rupture of a module, and faulty connections, can result in hot spots that can ignite combustible material in their vicinity. Wrongly installed or defect DC/AC inverters have been the reason of several photovoltaic fires as well.

In the worst case, faulty conditions on the photovoltaic system will not only result in a hot spot, but also a DC arc. Arcing has been found to be the main reason of larger rooftop fires on commercial buildings starting on PV systems and have gained a lot of attention.

Any disconnection or faulty connection of current carrying wire can cause an electric arc, which is the continuation of current flow through air. An arc-flash can occur when there is sufficient amperage and voltage and a path to ground or to a lower voltage. Any electric installation is exposed to the risk of arcs, but solar installations are particularly sensitive to this exposure because of the continuous DC current and the high currents (>10 A) and voltages (300-1000 V) involved. DC arcs do not self-extinguish and can reach temperatures as high as 3000°C (5400°F). Arcs at this temperature can melt metal, which can fall as slag and ignite nearby combustible materials.

There are three types of arcs:

7.5.4.1 Serial arc

Occurs when a connection is pulled apart while the PV is producing current. Typical reasons for serial arcs are loose connections or connector defects (e.g., in the soldered joints within the module). For this reason, special care also has to be taken when PV systems are isolated in a fire situation.

7.5.4.2 Parallel arc

Occurs when an insulation system suffers break-down. Two conductors of opposite polarity in the same DC circuit are often run in close proximity to each other. The insulation between the two wires can become ineffective due to animals chewing on them, UV breakdown, embrittlement, cracking, moisture ingress and freeze / thaw circles.

7.5.4.3 Ground arc

Arc on ground cables; requires the fault of only one insulation system.

In past fire incidents, defective soldering, loose connections, ground faults, isolation faults, aging / corrosion, and bites from rodents have resulted in arcing. Most of them (other than bites from rodents) were related to installation and material deficiencies. Considering that the operating life of a PV system is more than 20 years, the true fire incidence rate may not become apparent for another 10 to 20 years when aging of the materials will occur. Furthermore, typical PV systems on commercial buildings have hundreds and even thousands of connectors, increasing the probability of faults occurring.

Currently, there is no final solution on how to mitigate the DC arc risk. The first line of defence is the quality of the components and the installation and the presence of protective devices for the entire electrical system.

The so-called “DC arc-fault circuit interrupter (AFCI)”, which is required NFPA 70, [55], for PV rooftop systems > 80 V DC is rather a loss control than a loss prevention feature. The devices are intended to detect DC arcs and eliminate them before they become a fire hazard. However, there are no such marketable devices available currently. The purpose of the NFPA 70 requirement is to stipulate the development and there are ongoing activities being coordinated by Underwriters Laboratories.

Protecting PV systems from high voltage DC arcing faults appears to be a promising mitigation means. However, reliable detection of arc faults is a severe challenge and determination of the appropriate corrective action is difficult. Arcs must be reliably detected, without causing false alarms. Different techniques can be applied, such as voltage, current, radiated energy or a combination of these. Taking corrective actions once the arc has been detected is the second challenge. Furthermore, the correct action for serial arcs can exacerbate a parallel arc. To extinguish a serial DC arc, power production must be ceased and current flow in the DC circuit must be reduced to a very low level. Extinguishment of a parallel arc requires the opposite action: two DC conductors must be shortened to bring the DC voltage to zero. NFPA 70 currently only requires for protection from serial arcs

7.5.5 Plant and Equipment Layout

Photovoltaic systems on commercial and industrial buildings do not differ from installations on residential buildings other than in size and the fact that most are tied into the utility grid without onsite consumption and storage capacity (batteries). Currently, most solar installations are still made of rigid (crystalline silicon) photovoltaic modules, which are mechanically fastened to the roof. These solar modules are built up of cells and then arranged in strings and arrays:

7.5.6 Fire Fighting

Safely disconnecting a PV system in a fire situation should ideally result in DC currents and voltages reduced to levels which are no longer hazardous to fire fighters. However, this would require isolation of each individual module and currently, there is no economically feasible solution for such an isolation tool. The so called “fireman’s switch” has been launched on the German market. Additional isolators can be installed between strings / arrays and the inverter at roof top level to at least de-energize the main conduit leading from the roof to the inverter. These switches can be remotely actuated from a safe location.

Proper labelling of all components and live equipment, as well as adding information and documentation of the PV system to the emergency response plan and providing fast access to qualified electricians familiar with the installation are other key factors in supporting manual firefighting.

7.5.7 Fire Protection

Photovoltaic systems on commercial and industrial buildings are a relatively new fire risk and there are no proven, standard protection concepts currently available. “Fire” protection for photovoltaic systems is not a classical “fire extinguishing issue”; it is rather a matter of preventing fires from happening in the first place by protective devices and high installation standards, minimizing the combustible loading should they happen, and avoiding unnecessary hazards for the fire services.

Before installing photovoltaic systems on high value commercial and industrial properties, a fire protection / detection assessment must be conducted in order to determine if the fire risk can be minimized or if there is a potential for a catastrophic loss. As of today, there are no reliable means to eliminate the risk of arcing on DC photovoltaic systems and the installation of photovoltaic systems on commercial / industrial buildings with combustible roofs (entirely combustible or with combustible insulation) is strongly discouraged. If only components, such as the roof membrane of built-up roofs are combustible, further means of risk mitigation can be evaluated.

The following list consists of system design elements and loss prevention programs that can be used for minimizing the fire risk of photovoltaic installations. Codes and standards are not identical in the various regions of the world and protective devices are under development. The list has been kept general, however most items refer to rigid photovoltaic modules. There is very limited experience to date with building integrated photovoltaic systems (BIPV) and flexible photovoltaic modules.

7.5.7.1 Photovoltaic Panels

- Only PV modules which comply with international standards for electrical performance and safety should be used. The safety standards, such as IEC 61730 and ANSI/UL 1703 address the combustibility of the modules. There are no uniform standards for evaluating the combustibility of the modules as roof assemblies.
- Modules should have the approval / listing of an internationally recognized testing laboratory. Currently TÜV Rhineland tests the majority of panels (for compliance with international standards) and FM Approved panels are reportedly underway.
- When evaluating the combustibility of the modules, the mounting system and the module frames need to be considered as well. Mounting systems and frames should be non-combustible.
- In order to provide free space for fire fighters to access the building, the size of the arrays should be limited. The roof should have sufficient pathways and perimeter space around PV modules so that fire fighters can traverse the roof safely. The required safety distance of the modules from fire walls and heat and smoke vents should be in accordance with the respective fire protection standards.

7.5.7.2 Cables

- Only solar cables suitable for outdoor applications and severe weather conditions and UV radiation should be used. In the US, UL 4703 is applied since its release in 2005. In Europe, individual specifications per country are in use currently. The standards are not identical and when choosing solar cables, the fire performance should also be considered.
- Protecting cables from severe weather conditions and from UV radiation helps to slow down the aging process and thus minimizes the risk of hot spots and arcing. Cables should be fixed and routed in closed metal conduits; no loose cables should be allowed. Another means of minimizing the risk of arcing is routing positive and negative wires in separate conduits. Cables should not be run over sharp edges to avoid mechanical damage.
- Routing of solar cables should not compromise fire compartments of the building (e.g., by penetrating parapeted fire walls). If this cannot be avoided, the openings need to be enclosed and sealed in accordance with the respective standards for fire walls.
- Direct contact between cables or connectors and combustible roofing material, such as roof membranes, should be avoided. Cable conduits can be mounted on a steel structure and the area below the cables can be covered with a non-combustible material. Gravel has been used in some instances, however this additional weight may have a high impact on the roof load and lighter materials are preferred.
- The main DC cables from the PV panel to the inverter should not be routed through the interior of a building; instead they should run along the outside. If for any reason the cable needs to be routed through the interior of a building, it should be enclosed in a fire resistant duct, chute or other enclosure.

7.5.7.3 Inverters

- The inverter(s) should be easily accessible and protected from severe weather conditions. The preferred location is inside a separate non-combustible structure supervised by a fire detection system.
- Inverter(s) should not be mounted on combustible walls such as wood panels or combustible sandwich panels.

7.5.7.4 Disconnect Requirements

- A DC disconnector switch between the PV generator and the inverter should be provided, even if local electrical codes do not require this. This allows safe disconnection of a defect inverter or safe disconnection of modules for maintenance purposes. The DC disconnector can also be used in a fire situation.
- Additional DC disconnector switch(es) closer to the modules ("rooftop shut-off valve" or "fireman's switch") should be considered to support manual firefighting and de-energize major DC conduits with live currents and voltages. The switches should have remote actuators.

7.5.7.5 DC Arc Detection and Elimination

- The risk of DC arcs can be minimized in a high quality installation, however cannot be excluded and the use of DC arc detection and interruption devices for photovoltaic systems should be considered once approved devices are available.

7.5.7.6 Emergency Response

- PV systems should be labeled in a clear and systematic manner to ensure that technicians and fire fighters can quickly and easily identify key elements of the system. Standards for labeling are available in some countries.
- Pre-emergency plans and drawings for the fire department should include the fire hazard of the photovoltaic system and the disconnection means. The plan should also include contact details of eliable (24 hr availability) and qualified electricians familiar with the installation who are able to safely disconnect the system. Disconnecting photovoltaic systems should normally not be left to the fire department.
- The local fire department should be informed of and familiarized with the photovoltaic installation. They can be given a set of the plans to refer to in case of emergency.

7.5.7.7 Installation, Maintenance and Inspection

- PV systems should only be installed by qualified contractors. Training courses and certification processes are available.
- PV systems should be inspected regularly by qualified professionals.
- PV systems should be regularly checked for damage from rodents and other pests, which could compromise wiring or insulation.

7.5.7.8 Other

- Although not covered in this document, proper grounding of the photovoltaic installation along with overcurrent protection and possibly lightning protection are of paramount importance to avoid any electrical fault that could lead to hot spots and eventually arcing.

8. CONSTRUCTION SITE FIRE PROTECTION

8.1.1 General

Consideration should be made to both the safety of occupants during new build and refurbishment works, whilst also considering the impact upon existing buildings and infrastructure adjacent to any construction site. Given the uncertain nature of construction sites adequate measures should be adopted to ensure the continuity of services is not affected. The impact of a construction site fire can be significant, especially when resulting in loss of life, or the ability to generate power. Strict guidelines should be enforced to limit the impact of construction and refurbishment works. Further guidance can be found in relation to construction site fire safety within NFPA 850 [90].

8.1.2 Administration

Before any works commence on site a plan should be developed, documenting the following key items and procedures:

1) On site security team, and their roles and responsibilities. This may include a sign in-sign out system recording operative movements in and out of the construction site. This will allow all personnel to be accounted for should the building site require evacuation.

   Staff should be trained such that they can:

   - Notify the fire department and dedicated management personnel of the emergency situation developing.
   - Familiarise themselves with specific hazards in relation to fire such that they may be identified during any site wide patrols carried out.
   - Detail on recording security rounds carried out, which shall be carried through all areas of construction during times when construction activity is not in progress.

2) Develop a strategic plan to safeguard and protect any existing items of plant, equipment, or buildings, prior to works commencing. This may include the provision of fire barriers, walls, temporary standpipes and hydrants, and the possible upgrading of existing fire protection measures. Typically, as detailed within previous sections of this guide, any fire separation provided shall be rated to provide a minimum fire separation of 2 hours (120 minutes). The actual level of protection, which may be in excess of the 2 hours, should be determined during the preparation of the construction site fire risk assessment.

3) Develop a pre-fire action plan with the on-site fire brigade, and the Local Territorial Fire Authority to ensure any fire incident may be tackled without delay, and in a controlled manner.

4) As part of this action plan consideration to the provision of temporary communication should be provided. This may be in the form of radio communications where fixed communications facilities are not available on the construction site. This ensures all teams responding to an emergency, Security, Fire Wardens, On Site Fire Brigade, are aware of the developing situation and may assist.

5) Develop a fire evacuation plan, for all stages of the work to ensure operatives are aware of the escape routes and assembly points available to them. This plan should also take into consideration existing adjacent buildings and areas where escape routes may be affected by the construction work, and the introduction of temporary hoarding or fences.

8.1.2.2 Responsibilities

The responsibility for fire protection for the entire site during the construction period shall be defined prior to any works commencing on site.

The responsibility for fire protection programmes among various organizations on-site shall be outlined and defined prior to any works commencing to ensure all responsible personnel are aware of their role and responsibilities, and the actions to be implemented in the event of an emergency situation.

8.1.3 Pre-Construction Risk Assessment

Prior to any works commencing a site wide fire risk assessment should be carried to determine the likely hazards, the risks associated with this hazard, and the likely consequence should an event occur. This will allow appropriate measures to be put in place to ensure any incident can be tackled quickly and safely.

Written procedures shall be established for the new construction site, including major construction projects in existing plants, to allow safe working practices to be developed, whilst also ensuring the fire response is adequately planned, particularly when different programme phases may change access and egress points to and from the construction site.

Construction schedules shall be coordinated so that the planned permanent fire protection systems are installed and placed in service as soon as possible, at least prior to the introduction of any major fire hazards identified.

Where the implementation and installation of fire barriers, walls, fire seals, and fire doors etc. they shall be given priority in the construction schedule to restrict the possibility of fire spreading to and from what may be deemed as a hazard area/high priority area to be protected.

As a minimum the risk assessment and controls should detail:

- Fire safety information for all employees and contractors (i.e. familiarisation of emergency alarms and procedures, how to report a fire, who to report the fire to). This should be carried out during any site wide induction scheme implemented.
- Details of plant inspection dates, particularly where contractors provide their own equipment. An agreed weekly/fortnightly/monthly check should be scheduled to ensure the equipment being used is safe, and does not pose a fire hazard.
- Detail on the housekeeping measures to be adopted (i.e. refuge collection points, clean workplace strategy, ensuring site operatives remove their rubbish once works are complete, etc.)
- Control, storage, and handling of any flammable liquid or gas brought into, and used within, the boundaries of the construction site. Emphasis should also be placed on ensuring works adjacent to any existing, retained, in-use structure is well controlled, with the hazards and risks for those specific areas highlighted and controlled.
- Control of ignition sources, smoking, grinding, welding, cutting, hot works etc. Appropriate methods of working should be developed to ensure all operatives work in a safe manner, and are aware of their surroundings when carrying out such works. NFPA15B – Standard for fire prevention during welding, cutting, and hot works provides further details on the measures and controls that may be adopted.
- Fire report – outlining any incidents, their cause, the resulting damage, and the corrective action taken after the fire. This should be reviewed regularly to ensure any unsafe practices are highlighted early such that they may be controlled to limit their occurrence and frequency.
- Detail the onsite fire hazards, including detail on materials, plant, stored items, that are deemed to be hazardous so that all operatives are aware of the dangers posed by specific items prior to their use. The standard for identification of the hazards of materials provides further guidance, as well as specific applicable material safety datasheets provided by manufacturers for their materials. These should all be consulted where hazardous materials are to be used.

8.1.4 Access and facilities for Fire-fighting

A suitable location on the construction site shall be designated as a fire-fighting command post. Fire service vehicle access should be maintained to this designated command post to ensure the onsite fire service can assess the situation from this safe place.

The command post should contain a copy of:

- all plans of the construction site,
- a copy of the access and egress route plan,
- details on the location of fire-fighting equipment across the site that may assist with any situation,
- Temporary communication systems (i.e. hand held radios that are fully charged)
- Access to keys, locks etc. that may hinder their approach to the area on fire

During construction consideration should be made to providing a temporary road/route through the construction site such that the onsite fire service is able to access all areas. Consideration to the weight of the fire service vehicle should be made to ensure any temporary access route constructed is fit for purpose.

8.1.4.1.2 Temporary Hydrants

Where it is not possible to provide access to all areas of the construction site consideration should be made to installing any hydrant system planned for the facility at the earliest opportunity. This ensures the fire service has facilities to fight any fire situation from afar, should access directly adjacent to all areas be available. Spacing and location of the hydrants should be considered during the planning stage to ensure adequate coverage is provided across all areas. As a minimum, the number of hydrants, and the required flow rate from these hydrants should be as detailed within Section 5.10.

8.1.5 Site Clearing

The requirements of the National Veld and Forest Fire Act, NFPA and/or local authority shall be met.

Where any agreed approach is defined within the construction site fire-fighting strategy, the response shall be as follows:

A fire protection water supply should be provided on the construction site and should be capable of furnishing the largest of the following for a minimum of 2 h duration:

- 2 839 l/min (340.68 m^3 for 2 h water supply).

The in-service fixed water extinguishing system with the highest water demand and 1 200 l/min for hose streams as per SANS 10400 [55] (usually there will not be fixed fire protection systems in place during the early construction phase of a project).

Water supply should be sufficient to provide adequate pressure for hose connections at the highest elevation. Typical pressures are:

- Sprinkler system pressures = 900 kPa to 1 000 kPa.
- Hydrant systems = 350 kPa to 700 kPa (above 700 kPa, one person cannot handle a fire hose).

If water pressures cannot be met during the early phases of construction, boosting facilities shall be made available to boost the available water source pressure to a minimum of 350 kPa, as per Eskom minimum requirements.

If early fire-fighting strategies are not in place, only portable fire extinguisher or a water tanker arrangement may be considered.

8.1.6 Manual Fire-fighting

Portable fire extinguishers of suitable capacity should be provided in potential fire risk areas such as:

- Where flammable liquids are stored or handled.

- Where combustible materials are stored.
- Where temporary oil- or gas-fired equipment is used.
- Where a tar or asphalt kettle is used.
- Where welding, grinding, or open flames are in use.

Portable fire extinguishers shall comply with the requirements of SANS 1910 [43].

Fire extinguishers are to be located at positions close to potential fire risks. The minimum number of fire extinguishers to be provided are as follows (the actual number should be determined during the site fire risk assessment carried out prior to any construction or demolition work taking place):

- 9 kg Dry Chemical Powder (DCP) fire extinguishers that shall be positioned in the majority of site/plant areas.
- 5 kg CO_2 (carbon dioxide) that essentially will be positioned in electrical switchgear rooms, substations and control rooms.

Fire hydrant hoses and nozzles should be available at strategic locations, such as inside hose cabinets or hose houses or on dedicated fire response vehicles. Any fire hose connections provided should be compatible with local authority fire-fighting equipment, and the equipment used by the onsite fire service response team.

Contractors on site shall ensure that required people are trained in the handling of the fire-fighting equipment available to them, and are aware of the procedures for raising an alarm. This shall include detail on the key security team members to be contacted, and a contact number/details for the onsite fire brigade. This information should be provided as part of any site induction plan implemented across the construction site.

8.1.7 Temporary Construction Materials

Where temporary scaffoldings and platforms are used inside or outside of near completed buildings, if there is the possibility they may cause serious damage to the building, fire retardant equipment should be used. This is particularly relevant where finishing materials are being applied, which are typically designed to restrict the surface spread of flame across a building, and may not be installed.

9. AUTHORISATION

This document has been seen and accepted by:

Name	Designation
	First Revision Document Approved by TDAC ROD 16 July and Special Approval 18 October 2013
Marlize André	Chairperson – Fire and Life Safety Care Group
Cobus Dippenaar	Member – Fire and Life Safety Care Group
Marius Atterbury	Member – Fire and Life Safety Care Group
Mbali Mathebula	Member – Fire and Life Safety Care Group
Jorge Nunes	Member – Fire and Life Safety Care Group
Andre van den Berg	Member – Fire and Life Safety Care Group
Warren Reid	Member – Fire and Life Safety Care Group
Brian Lintnaar	Member – Fire and Life Safety Care Group
Omry Makgoale	Chairperson – Fuel Handling Systems Care Group

Name	Designation
Jan Strydom	Chairperson – Water Distribution Systems Care Group
Anasen Pillay	Chairperson – General Mechanical Care Group
Rayen Naidoo	Chairperson – HVAC Care Group
Mary Maunye	Chairperson – H_2/N_2/Compressed Air Care Group
Mamosa Mosebo	Participant – Fire and Life Safety Care Group
Mphephu Nengovhela	Participant – Fire and Life Safety Care Group
Siyabonga Zwane	Participant – Fire and Life Safety Care Group
Cinga Mhlongo	Participant – Fire and Life Safety Care Group
Lyborn Xivambu	Participant – Fire and Life Safety Care Group
Wesley Nkwinika	Participant – Fire and Life Safety Care Group
Cindy Ndlangisa	Participant – Fire and Life Safety Care Group
Viona Lutchminarain	Participant – Fire and Life Safety Care Group
Seshni Pillay	Participant – Fire and Life Safety Care Group
Nelly Hlophe	Participant – Fire and Life Safety Care Group
Bernard Van Der Westhuizen	Participant – Fire and Life Safety Care Group
Theodore Subramoney	Participant – Fire and Life Safety Care Group
Alusani Ndou	Participant – Fire and Life Safety Care Group
Reymond Mogajane	Participant – Fire and Life Safety Care Group
Mauritz Van Der Bank	Participant – Fire and Life Safety Care Group
Didi Tselane	Participant – Fire and Life Safety Care Group
Nsizwa Mhlongo	Participant – Fire and Life Safety Care Group
Henri Kotze	Participant – Fire and Life Safety Care Group
Simphiwe Kubheka	Participant – Fire and Life Safety Care Group
Kamogelo Lefifi	Participant – Fire and Life Safety Care Group
Phaks Antoni	Participant – Fire and Life Safety Care Group
Zanele Mani	Participant – Fire and Life Safety Care Group
Mohammed Sardiwalla	Participant – Fire and Life Safety Care Group
Nompilo Miya	Participant – Fire and Life Safety Care Group
Sibusiso Ngcobo	Participant – Fire and Life Safety Care Group
Tiisetso Ntlatleng	Participant – Fire and Life Safety Care Group
Nombuyiselo Molosiwa	Participant – Fire and Life Safety Care Group
Peter May	Fire Risk Management
Hardus Viljoen	Fire Risk Management
Marius Engelbrecht	Fire Risk Management
Nkosi Ndika	CoE Manager (Acting) – Low Pressure Services
Danie Odendaal	General Manager - Plant Engineering
Prince Moyo	General Manager - Power Delivery
Titus Mathe	Senior Manager - Power Plant
Prudence Madiba	Senior Manager - Electrical and C&I

Name	Designation
Vasanie Pather	Senior Manager - Auxiliary and Chemical
Galia Dudenska	Senior Manager - Civil, Structural and Hydro
Louis Fernandez	Senior Manager - Integration
Power Delivery Engineering SCOT Committee	

10. REVISIONS

Date	Rev.	Compiler	Remarks
October 2012	0	M D Collier	First draft for comment
March 2013	0.1	M D Collier	Final Draft for Review
July 2013	1	M D Collier	Final Rev 1 Document for Authorisation
May 2014	1.1	M D Collier	First revision draft for comment process
August 2014	1.2	M D Collier	Final Updated Draft for Comments Review
October 2014	2	M D Collier	Final Rev 2 Document for Authorisation and Publication

11. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- Marlize André – Eskom Group Technology
- Matthew Collier - Eskom Group Technology
- Chris Barrett – WSP Group
- Frank Mendham – WSP Group
- Walther Groenewald – WSP Group
- Karel Roodt – WSP Group

12. ACKNOWLEDGEMENTS

- Cobus Dippenaar
- Mbali Mathebula
- Marius Atterbury
- Marius Engelbrecht
- Jorge Nunes

13. ANNEXURE A: FIRE PROTECTION REQUIREMENTS – AREA AND SYSTEM

This section aims to address the most appropriate systems and technologies to use within each specific area of the Eskom asset, which will provide the best protection.

The proposed systems are combinations of codes, standards, industry best practice and experience. Table 6 serves as a quick reference guide ONLY.

In most cases, this section provides more than one option for each area, as there will very rarely be only one option which will always be the best choice. It shall be the responsibility of the user of this document to decide which system, if any, is to be used.

The inappropriate selection of fire protection equipment in a power utility environment may contribute to unnecessary false alarms, slow detection times of fires, high installation and maintenance costs, increased outages and potentially unwanted ignition sources within hazardous areas representing a fire and explosion hazard. This could possibly be the cause of subsequent risk to life safety and asset loss.

A balance is also required between simple and sophisticated fire protection technology, which must be appropriate to the operating environment.

Even though this document basically allows for a Deemed to Satisfy approach and a Rational Alternative Code Compliant Design, there will always be factors which cannot be accounted for and will require a Rational Fire Engineered Design. Such factors are:

- Suitability of the Fire Protection system components;
- Nature of the site, buildings and equipment;
- Environmental and atmospheric factors specific to the area such as temperatures, humidity, wind, dust, and smog, etc. Particularly in relation to how the fire protection system is to be actuated.
- Operations in the areas;
- The level of monitoring and control required for the site as a whole;
- The personnel occupying the buildings as well as using and monitoring the Fire Protection and Fire Detection systems;
- Areas not covered in the documents.

The determination of which of the above approaches to use for carrying out the fire protection system selection and design is detailed in the Fire Protection/Detection Assessment [2] standard.

Table 12: Area versus System Protection

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage	Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Fluids	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Emergency Exit & Escape Route Signage	
Location / Equipment to be protected	**System Types**																											**Comments**
General Site Wide Requirements				x									x	*	x		x										x	*The requirement for hose reels and fire extinguishers is to be determined during preparation of the Fire Protection/Detection Assessment.
Plant Specific Fire Protection Requirements - Fuel Handling																												
Fuel Handling & Storage – Gas																												
LPG				x		x							x					x	x			x					x	
Hydrogen				x		x							x					x	x			x					x	
Fuel Handling & Storage – Oil																											x	
Indoor fuel oil pumping or heating facilities			*x	x	x	x			x	x								x	x			x					x	*Where indoor pumping facilities are provided as part of the oil handling facilities ventilation should be provided to prevent the build-up of flammable vapours.
Outdoor fuel handling & Storage Areas						x			x			x	x									x					x	
Fuel Handling & Storage – Coal																											x	
Bins, Bunkers, Silos (SEE NFPA 85)				x					x	x			x									x				x	x	
Boiler House & Bunker/Silo separation																		x	x			x					x	

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage	Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Emergency Exit & Escape Route Signage	
Location / Equipment to be protected	**System Types**																											**Comments**
Critical - Coal conveyers																												
Coal conveyers - handling areas				x	x	x													x		x					x	x	
Coal conveyers - Stock reclaimers					x					x									x		x					x	x	
Critical Coal Conveyor				x	x														x		x						x	
Conveyor Enclosed Electrical Control Cabinets							x			*x																		
Non critical (below grade or enclosed) Conveyors				x	x														x		x						x	
Steam Generator & Associated Equipment																												
Boiler Furnaces - multiple oil burners				x	x	x			x	x									x									
Pulverisers / Mills										x			x	x														
Feed Pumps						x						x									x							
Air Pre-Heaters				x		x																						
Scrubber Buildings (with non-combustible linings)				x	x																		x				x	**Automatic opening heat vent required to the Scrubber Building**
Turbine Generator & Associated Equipment																												
Hydraulic Control Systems																					x							
Hydraulic Control Systems (without fire resistant fluid)				x	x				x																			
Lubricating Oil Systems				x	x	x			x	x	x	x	x	x														

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage	Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Emergency Exit & Escape Route Signage	
Location / Equipment to be protected	**System Types**																											**Comments**
Turbine Generator Area				x	x	x			x			x															x	
Lubricating oil equipment in a separate enclosure to the generator				x		x			x			x																
Seal Oil Unit				x		x			x			x																
Turbine Generator Bearings				x	x	x			x			x																*Consideration should be made during the Fire Protection/Detection Assessment process as to whether suppression protection should be included.
Oil Pipe Galleries				x	x	x						x																
Electrical Equipment																												
Control Room	x	x					x			x												x					x	
Computer / Communications Room				x	*x		x			x																	x	*Consideration should be made during the Fire Protection/Detection Assessment process as to whether sprinkler or water mist systems should be included.
Raised floors containing cables							x			*x																		*As an alternative to a total room gas flooding system, individual items of equipment, or cabinet protection could be considered during the Fire Protection/Detection Assessment process.
Enclosures containing high value or critical equipment to power generation							x			*x																		
Cable Spreading Rooms	x			x	x		x		x	x												x					x	
Cable Tunnels	x			x	x		x		x	x												x					x	
Switchgear & Relay Rooms							x			x												x					x	
Battery Rooms							x			x												x					x	
SCADA & RTU Rooms							x			x												x					x	
Substation and switch yards				x			x			x			x	x								x					x	

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage	Fire Hydrant s	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Emergency Exit & Escape Route Signage	
Location / Equipment to be protected	**System Types**																											**Comments**
Transformers																												
Outdoor oil insulated transformers *(containing 1890litres of oil or more)*				*x		*x						*x	x									*x			*x			*Where possible any outdoor oil filled transformer should be separated from other areas as per the Separation Distance Requirements detailed within Section 4. Separation shall be in the form of a 2 hour fire wall designed to meet the requirements of Section 5.1.4 of NFPA 850.Should a fixed suppression system be provided to protect the transformer the rating of the fire wall may be reduced to 1 hour."
Indoor oil insulated transformers *(containing 379litres of oil or more, or having an electrical rating exceeding 35 kV)*				*x		*x						*x											*x				x	*Indoor transformers should be separated from all adjacent areas via 3 hours fire resistant construction. Should a fixed suppression system be provided to protect the transformer the rating of the fire wall may be reduced to 1 hour.
Oil Drainage Pits: Rock Filled Pits																												Rock filled pits do not require fixed protection system as the 'rocks' act as an extinguishing agent by restricting air to the fuel and smothering the fire.
Oil Drainage Pits: Open Pits				x	x	x						x	x															Where a 12inch thick layer of rock located between the steel plate and the drainage pit is provided no suppression is required.

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage	Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Emergency Exit & Escape Route Signage	
Location / Equipment to be protected	**System Types**																											**Comments**
Auxiliary Equipment & Other Structures																												
Emergency Generators				x	x	x	x		x			x										x					x	
Store Rooms / Offices / Shops				x	x		x					x	x	x		x						x					x	
Warehouses / Maintenance Shop				x	x							x	x	x		x						x					x	
Fire Pump Rooms				x	x	x	x		x			x										x					x	
Cooling Towers																						x						
Auxiliary Boilers				x	*x	x			x	x									x			x						*In the first instance an automatic sprinkler system is the preferred method of suppression to be considered.
Air Compressors				*x	*x																	x						*During the Fire Protection/ Detection Assessment process the requirement to protect oil filled electrical equipment should be evaluated to determine whether the hazard warrants full scale suppression protection to control the risk of fire, and whether suitable automatic detection may be considered in its place.

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage	Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Emergency Exit & Escape Route Signage	
Location / Equipment to be protected	**System Types**																											**Comments**
Hydro Power Stations																												
Unattended Hydro Plants																												Consideration to the fire protection requirements, in particular their remote control and monitoring, and the response time of the fire service or any Eskom fire response team should be considered during the Fire Protection/Detection Assessment, with water supplies and fire protection systems designed and selected accordingly.
Oil Cooled Circuit Breakers																							x					
Hydraulic Control System				x	x				x	x	x	x									x	x						*During the Fire Protection / Detection Assessment process the requirement to provide suppression protection to these areas should be evaluated based upon the hazard and associated risk of fire.
Turbine Bearings				*x	*x				*x													x						*During the Fire Protection / Detection Assessment process the requirement to provide suppression protection to these areas should be evaluated based upon the hazard and associated risk of fire.

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO2 Suppression System	Containment & Drainage	Fire Hydrant s	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Portable Extinguishers (as required by the Fire Protection / Detection Assessment process)	
Location / Equipment to be protected	**System Types**																											**Comments**
Lubricating Oil Systems				x	x				x				x	x								x						*During the Fire Protection / Detection Assessment process the requirement to provide suppression protection to these areas should be evaluated. Where protection is included it should also cover reservoirs, pumps, and all oil lines.
Generator Pit & Windings				x		x				x												x						
Control, Computer, Communication Rooms	x	x		*x	*x		x															x						*Consideration should be made during the Fire Protection / Detection Assessment process as to the type of fixed fire protection system to be installed based upon the hazard and associated risk of fire.
Raised floors containing cables							x			*x																		*As an alternative to a total room gas flooding equipment individual items of equipment, cabinet protection could be considered during the Fire Protection / Detection Assessment process.
Enclosures containing high value or critical equipment to power generation							x			*x																		
Cable Concentrations				x	x	x	x		x	x		x																

Active & Passive Fire Protection Systems		Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation		Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	**Pre-Action Sprinkler System**	Foam Type Suppression System	Gaseous Suppression System	CO2 Suppression System	Containment & Drainage		Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks		Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables		Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction		Portable Extinguishers (as required by the Fire Protection / Detection Assessment process)	
Location / Equipment to be protected		**System Types**																																**Comments**
Cable Tunnels						x	x		x		x			x													x							*During the Fire Protection / Detection Assessment process the requirement to provide suppression protection and heat detection to these areas should be evaluated based upon the hazard and associated risk of fire.
Transformers																																		
Outdoor oil insulated transformers *(containing 1890litres of oil or more)*						*x	*x	*x			*x			*x		*x											*x			*x				*Where possible in the first instance, any outdoor oil filled transformer should be separated from adjacent areas as per the Separation Distance Requirements detailed within Section 4. Separation shall be in the form of a 2 hour fire wall designed to meet the requirements of Section 5.1.4 and Figure 5.1.4.3 within NFPA 850. Should a fixed suppression system be provided to protect the transformer the rating of the fire wall may be reduced to 1 hour.
Indoor oil insulated transformers *(containing 379litres of oil or more, or having an electrical rating exceeding 35 kV)*						*x	*x	*x			*x		*x															*x						*Indoor transformers should be separated from all adjacent areas via 3 hours fire resistant construction. Should a fixed suppression system be provided to protect the transformer the rating of the fire wall may be reduced to 1 hour.

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	**Pre-Action Sprinkler System**	Foam Type Suppression System	Gaseous Suppression System	CO2 Suppression System	Containment & Drainage	Fire Hydrant s	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Portable Extinguishers (as required by the Fire Protection / Detection Assessment process)	
Location / Equipment to be protected	**System Types**																											**Comments**
Indoor Oil Filled Electrical Equipment				*x	*x	*x			*x													x						*During the Fire Protection / Detection Assessment process the requirement to protect oil filled electrical equipment should be evaluated to determine whether the hazard warrants full scale suppression protection to control the risk of fire, and whether automatic detection would be sufficient.
Clean & Dirty Oil Store Rooms				*x	*x				*x		*x																	*The level of protection provided to the Clean & Dirty Oil Stores should be determined during the Fire Protection / Detection Assessment process based upon the hazard posed and the risk of fire.
Battery Rooms							x			x												x						
Switchgear & Relay Rooms							x			x												x						
Emergency Generators				*x	*x	*x	x		*x	*x												x						*Consideration should be made during the Fire Protection / Detection Assessment process as to the type of fixed fire protection system to be installed based upon the hazard and associated risk of fire.
Air Compressors				*x	*x																	x						*During the Fire Protection / Detection Assessment process the requirement to protect oil filled electrical equipment should be evaluated to determine whether the hazard warrants full scale suppression protection to control the risk of fire, and whether suitable automatic detection may be considered in its place.

Active & Passive Fire Protection Systems		Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation		Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	**Pre-Action Sprinkler System**	Foam Type Suppression System	Gaseous Suppression System	CO2 Suppression System	Containment & Drainage		Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks		Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables		Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction		Portable Extinguishers (as required by the Fire Protection / Detection Assessment process)	
Location / Equipment to be protected		**System Types**																																**Comments**
Hydraulic Systems for Gate & Valve Operators						*x	*x				*x														x		x							*Where non fire rated hydraulic fluids are proposed, and the Fire Protection / Detection Assessment process highlights the hydraulic system to be a specific hazard, the system should be protected by a fixed fire protection system. Should the Risk Evaluation Process not highlight the hydraulic system as a specific hazard suitable automatic detection should be considered.
Fire Pump Rooms						*x	*x	*x	x			*x															x							*Consideration should be made during the Fire Protection / Detection Assessment process as to the type of fixed fire protection system to be installed based upon the hazard and associated risk of fire.
Storage Rooms, Offices, and Shops						*x	*x																				x							
Warehouses / Maintenance Shop						*x	*x																				x							*During the Fire Protection / Detection Assessment process the warehouse areas should be assessed to determine whether they contain high value equipment and / or combustible materials that are critical to power generation, and require a fixed fire protection system to be installed.

Active & Passive Fire Protection Systems	Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation	Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	**Pre-Action Sprinkler System**	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage	Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks	Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables	Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction	Portable Extinguishers (as required by the Fire Protection / Detection Assessment process)	
Location / Equipment to be protected	System Types																											**Comments**
Wind Farms																												
Nacelle with generator, transformer, hydraulic systems, gearbox, brake, azimuth drive							x			x	*x															*x		*During the Fire Protection / Detection Assessment process the requirement to protect should be evaluated to determine whether the hazard warrants full scale suppression protection to control the risk of fire, and whether automatic detection & shutdown or preventative measures would be sufficient.
Hub with pitch drive and generator (if applicable)							x			x	*x															*x		
Raised floors with oil sump, cable and electrical installations				*x	*x	*x	x		*x	x	*x	*x																
Central electrical power substation, switchgear rooms (without transformers)							x			x	x																	
Tower base/platform installations (if applicable)				*x	*x	*x	x			*x		*x																
Control, inverter, switchgear cabinets (LV/MV), cabinets open							x				*x																	
Control, inverter, switchgear cabinets (LV/MV), cabinets closed							x			*x	*x																	
Hydraulic systems open				*x	*x	*x			*x		*x	*x																
Outdoor oil insulated transformers (containing 500gallons, 1890 litres of oil or more)				*x		*x			*x			*x										*x			*x			*Where possible in the first instance, any outdoor oil filled transformer should be separated from adjacent areas as per the Separation Distance Requirements detailed within Section 4. Separation shall be in the form of a 2 hour fire wall designed to meet the requirements of Section 5.1.4 and Figure 5.1.4.3 within NFPA850.
Solar Power Station (CSP)																												
HTF Pump and pipe racks					*x																							

Active & Passive Fire Protection Systems		Smoke Ventilation	Pressurised Air Conditioned Space	Flammable Vapour Ventilation		Water Supply to Permanent Fire Protection Systems (2hours supply)	Automatic Sprinkler System	Water Deluge System	Aerosol System	Pre-Action Sprinkler System	Foam Type Suppression System	Gaseous Suppression System	CO_2 Suppression System	Containment & Drainage		Fire Hydrants	Hose Reels and Fire Extinguishers	Fire Pumps	Pumper Connection for Fire Service	Water Supply Tanks		Fuel Storage & Dedicated Piping / Pumping System	Shut Off, Control, & Sensing Valves	Plant Shutdown & Interlocks	Fire Resistant Hydraulic Cables		Fire Resistant Construction (2 hours separation)	Fire Resistant Construction (3 hours separation)	Fire Resistant Construction (4 hours separation)	Separating Distance from Adjacent Structures	Non-combustible Construction		Portable Extinguishers (as required by the Fire Protection / Detection Assessment process)	

Location / Equipment to be protected		System Types																															Comments
Steam Turbine Area							*x	*x			*x																						x	
Generator								x		x		x															x						x	
Multiple oil fired burners in heater							x	x			x																						x	
Solar field providing coverage to HTF piping associated with solar collection assemblies and HTF supply & distribution piping																x																	x	
Cooling Towers																											x							
Control Room		x	x			x	x		x			x	x														x						x	
Computer / Communications Room						x	*x		x			x	x																				x	
Cable Spreading Rooms		x				x	x	x	x			x															x						x	
Cable Tunnels		x				x	x	x	x			x															x						x	
PV Panel Installation																																		
Rigid Photovoltaic Panels						x										x											x				x		x	
External Areas						x										x																		
Offices		x				x										x	x										x				x		x	
Data Halls		x																									x				x		x	
Service Passages in Data Areas																	x										x				x		x	
Electrical Plant Rooms																											x						x	
Transformer Rooms																											x						x	
Diesel Tank Rooms		x				x					x						x										x						x	
Generators																	x										x						x	